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**EXPANDED SITE INVESTIGATION
DEAD CREEK PROJECT SITES
AT CAHOKIA/SAUGET, ILLINOIS
FINAL REPORT
VOLUME 1 OF 2**

May 1988

Prepared for:

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EXECUTIVE SUMMARY

The Dead Creek Project sites, or Sauget Sites, are located in west-central St. Clair County, Illinois, directly across the Mississippi River from St. Louis, Missouri. The project area consists of 12 suspected uncontrolled hazardous waste sites, and six segments of Dead Creek, which is an intermittent stream flowing southerly in the eastern portion of the project area. The project sites consist of former municipal and industrial waste landfills; surface impoundments or lagoons; surface disposal areas; and past excavations thought to be filled or partially filled with unknown industrial wastes. Waste disposal activities in the area apparently began sometime prior to 1940, and continued until approximately 1983, which marks the most recent available file information concerning active waste disposal at the project sites.

To avoid confusion stemming from various file designations or aliases for the various sites or creek sectors, each site or creek sector has been assigned an alphabetical designation. Additionally, sites were grouped into areas based on geographical relationship, common ownership or operation, and similar waste types and exposure pathways.

Several of the project sites have previously been investigated by the Illinois Environmental Protection Agency (IEPA), the United States Environmental Protection Agency (USEPA), and various consultants for the agencies or for area industries. These investigations focused, for the most part, on environmental problems in Dead Creek and the surrounding area, and on the disposal sites adjacent to the Mississippi River. The investigations indicated that significant and widespread contamination

existed in the project area, and raised concern that additional unidentified source areas may be contributing to the general degradation of air, surface water, and groundwater quality in the area.

Based on the findings of the initial investigations and media sampling, IEPA attempted to obtain federal funding for remedial action at two of the project sites through the Hazard Ranking System (HRS) scoring process, which employs a numerical model to prioritize uncontrolled waste sites across the country. In this process, sites that score above a designated cutoff point are placed on the National Priorities List (NPL), and become eligible for federal funding for cleanup under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. Sites that qualify for the NPL proceed to the remedial process, which, in short, includes a remedial investigation/feasibility study (RI/FS), remedial design, and remedial action. The purpose of the RI/FS is to define the extent of contamination and the risks associated with the migration of contaminants, and to screen alternatives for cleanup. The most appropriate alternatives are typically tested on a small scale, and the most cost-efficient and effective alternative is selected to be designed for full-scale operation at the site. The process culminates with the implementation of the remedial option in the field.

The initial attempts to qualify the Dead Creek Project sites for the NPL were unsuccessful because sufficient background information and analytical data were not available to address several specific elements of the HRS model. IEPA subsequently determined that the best available option for funding site remediation was to conduct more detailed site investigations designed to develop a sufficient data base for HRS scoring. In 1985, IEPA authorized an expanded site investigation (SI) to accomplish these objectives.

Preliminary SI activities began in October 1985, and field investigations were conducted during the period from November 1986 to July 1987. Geophysical investigations, consisting of magnetometry and electromagnetic induction surveys, were conducted at project sites in the vicinity of Dead Creek. A semiquantitative soil gas monitoring survey was conducted to enable more efficient placement of soil borings and monitoring wells. A total of 96 sample locations were analyzed

during the soil gas survey. Surface soils were sampled at 43 locations at two of the project sites. Thirteen surface water and 33 sediment samples were collected across four segments of Dead Creek. A total of 75 subsurface soil samples were collected from 51 borehole locations across the project area. Shallow monitoring wells were installed at 35 locations, and hydraulic conductivity tests were conducted at 15 of the wells. A total of 56 groundwater samples were collected from new and existing monitoring wells and from five private wells. Air sampling was conducted over a two-day period at six locations near Dead Creek and six locations around the sites adjacent to the Mississippi River.

The geophysical investigations indicated the presence of large quantities of buried ferrous metal objects (possibly drums) at two of the four sites surveyed. The areas indicated as anomalous in the surveys at these two sites correspond to the boundaries of large excavated areas seen in historical aerial photographs. Survey results from the remaining two sites did not indicate any significant differences between on-site and background conditions.

The soil gas test results identified several locations with high volatile organic concentrations at depths ranging from 3 to 5 feet below ground surface. The locations that showed the highest concentrations corresponded to the excavated areas identified in historical aerial photographs. The results of the soil gas survey provided a basis for locating the soil borings and monitoring wells.

Analysis of the surface soil samples revealed high concentrations of organic contaminants over the entire surface of a site adjacent to Dead Creek. Based upon the sample results for this site, a fence was constructed and warning signs were posted in order to restrict access to the general public. No organic contaminants were detected in surface soil samples from the second site tested.

Analysis of sediment samples from Dead Creek revealed the presence of organic and inorganic contaminants in each creek segment sampled. The highest concentrations of contaminants were detected in the northern portion of the creek, in areas reported to have received discharges from area industries in the past. Eight sediment samples were analyzed specifically for dioxin. This compound was not detected in any of the samples analyzed. Organic contaminants were detected only in surface

water samples from the two northern segments of Dead Creek. These two segments of the creek are, in effect, impoundments due to the blockage of culverts at each end of the segments. Because Dead Creek originates in an industrial area where the highest contaminant concentrations were detected, no upstream, or background, data could be collected for the creek.

Analysis of the subsurface soil samples revealed widespread contamination across each of the sites sampled. Several samples collected from sites adjacent to the northern portion of Dead Creek contained total organic contaminant concentrations in excess of 10,000 parts per million (ppm). Contaminants were detected in samples collected to a maximum depth of 50 feet at these sites. Although the most significant subsurface contamination was detected at the sites adjacent to Dead Creek, a variety of organic contaminants was also detected at each of the other project sites at which subsurface samples were collected. These analytical results indicate that the disposal of chemical wastes occurred at most of the former excavations identified in historical aerial photographs.

Analysis of groundwater samples from the various project sites revealed the presence of organic contaminants in groundwater at each of the sites sampled. The hydrogeological investigation confirmed that contaminants are migrating in groundwater in a westward direction toward the Mississippi River. The analytical and physical results of the hydrogeological investigation indicate that each of the project sites is contributing, to some degree, to the general degradation of groundwater quality in the area.

The analytical results from the air sampling investigation indicate a release of several organic contaminants from the sites sampled. Downwind air samples contained low levels of PCBs and several semivolatile compounds. Background, or upwind, samples did not contain these compounds, providing documentable evidence of a release of airborne contaminants resulting from conditions at the sites sampled.

Based on all of the data developed during this investigation, substantial and widespread contamination of various media (groundwater, soils, surface water, sediment) exists in the project area. The most significant contamination is found at the sites adjacent to Dead Creek

and the sites adjacent to the Mississippi River. Although source areas have been identified, and, to a certain degree, defined, the complete extent of contamination resulting from past waste disposal activities in the project area has not yet been determined.

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1. INTRODUCTION

This Expanded Site Investigation report was prepared for the Illinois Environmental Protection Agency (IEPA) to present and interpret the findings of investigations conducted at the Dead Creek Project (DCP) sites and creek sectors, located in the towns of Sauget and Cahokia in St. Clair County, Illinois. The report will be used to supplement existing data on the DCP sites and creek sectors, and provide a basis for assessment and remediation.

The DCP area will be evaluated against listing criteria for the State Remedial Action Priority List (SRAPL) and the National Priorities List (NPL) under the terms of the Illinois Environmental Protection Act and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), respectively. The DCP was originally planned as a Remedial Investigation/Feasibility Study (RI/FS), with the RI data to be used to aid in the preparation of the FS. Following a review of the existing file information on the DCP sites, it was determined that the original scope of work would not provide sufficient data for complete evaluation of the sites under the Hazard Ranking System (HRS) scoring mechanism. In view of the scope of work modifications and the re-assessment of project objectives, IEPA determined that the project would be more accurately described as an Expanded Site Investigation (SI). The SI scope of work, as modified in August 1986, included field investigations that would provide a data base which contained additional

HRS scoring data. These data would facilitate a more accurate assessment of the sites and enable a determination of whether any or all the sites should be included on the SRAPL or NPL. In addition to providing this data base, the purpose of the SI was to assess the cause, extent, and effects of hazardous materials in the project area. The FS portion of the project was subsequently indefinitely postponed. Specific goals of the SI included the following:

- Locate and define types and quantities of hazardous materials at the DCP sites;
- Provide a detailed description of area hydrogeology and its effect on contaminant migration and fate;
- Provide a comprehensive catalog of wastes present at the various project sites;
- Where possible, locate or define sources of contaminant releases;
- Identify past, present, and anticipated methods or pathways of contaminant release, and specific contaminants released;
- Assess the expected movement of contaminants in the matrices sampled, and identify potential receptors of contaminants; and
- Provide a data base for HRS scoring of the sites.

The SI was performed by Ecology and Environment, Inc. (E & E) for IEPA under Professional Services Agreement No. LCU-32, executed in September 1985. A Work Plan was prepared based on a review of file information from the various involved agencies, and on the results of previous investigations of the DCP area.

The following is a brief description of the elements included in the Work Plan and its attachments:

- Work Plan - Described the scope of activities to be performed for the SI and provided a detailed description of the specific task elements of the project.
- Sampling Plan - Presented the scope and objectives of sampling to be conducted; specific procedures for sample collection, preparation, and handling; sample matrices and locations; personnel requirements and site logistics; and procedures for documentation of samples and investigations.
- Quality Assurance Project Plan (QAPP) - Described quality assurance (QA) objectives; sampling procedures; chain-of-custody procedures; analytical procedures; internal quality control (QC) procedures such as collection and analysis of blank, duplicate, and spike samples; and data assessment procedures for accuracy, precision, and completeness.
- Health and Safety Plan - Addressed site and waste characteristics, site entry procedures, and types of personnel protective gear required for each task to minimize exposure to hazardous materials on-site and off-site.
- Community Relations Plan - Prepared in cooperation with IEPA, identified issues and concerns of area residents and proposed methods of distributing information concerning the project to the communities involved.
- Permitting Requirements Plan - Limited to a statement that no permitting would be required for the initial phase of the project.

The scope of work revision was an addendum to the Work Plan. This addendum identified sample matrices, numbers, and locations that

differed from those stated in the original Work Plan. An addendum to the QAPP was also prepared to describe sampling and analytical procedures for air sampling, which was not included in the original scope of work.

This report presents and interprets the findings of the SI performed at the DCP. The report is based on data obtained during the SI, and documents the site investigation activities, analytical results, and conclusions.

The report is organized into seven main sections. Section 2 presents a description and summary history of the DCP sites and creek sectors, including the results of previous investigations. Section 3 describes the procedures employed for the various SI field activities. Section 4 presents the physical and chemical data collected during the SI and the interpretation of the data. Section 5 discusses contaminant loading to the Mississippi River based on computer modeling. Section 6 presents a discussion of contaminant transport, fate, and impact associated with contamination at the sites and creek sectors. Section 7 presents findings and conclusions concerning the nature and extent of contamination at the DCP.

2. SITE BACKGROUND

2.1 SITE DESCRIPTION

The DCP area is located in and around the cities of Sauget (formerly Monsanto) and Cahokia in west-central St. Clair County, Illinois (see Figure 2-1). The project area consists of 12 suspected uncontrolled hazardous waste sites, and six segments of Dead Creek, which is an intermittent stream flowing southerly in the eastern portion of the project area. To avoid confusion stemming from various file designations or aliases for the various sites or creek sectors, each site or creek sector has been assigned an alphabetical designation (see Figure 2-2). The disposal sites occupy approximately 220 acres.

The scope of work revision submitted to IEPA in August 1986 included the concept of grouping several sites and creek sectors together for future Hazard Ranking System (HRS) scoring purposes. Sites were grouped into areas based on geographical relationship, same ownership or similar operation, and similar waste types and common exposure pathways. Sites grouped into areas included Sites G, H, I, L, and Creek Sectors A and B (Area 1), and Sites O, Q, and R (Area 2). These areas are presented in Figure 2-3. Sites J, K, M, N, and P do not meet requirements for site aggregation and will be referred to henceforth as peripheral sites.

The DCP sites consist of a number of former municipal and industrial waste landfills; surface impoundments or lagoons; surface disposal areas; past excavations thought to be filled or partially filled with unknown wastes; and an areal drainage flowpath (Dead Creek).

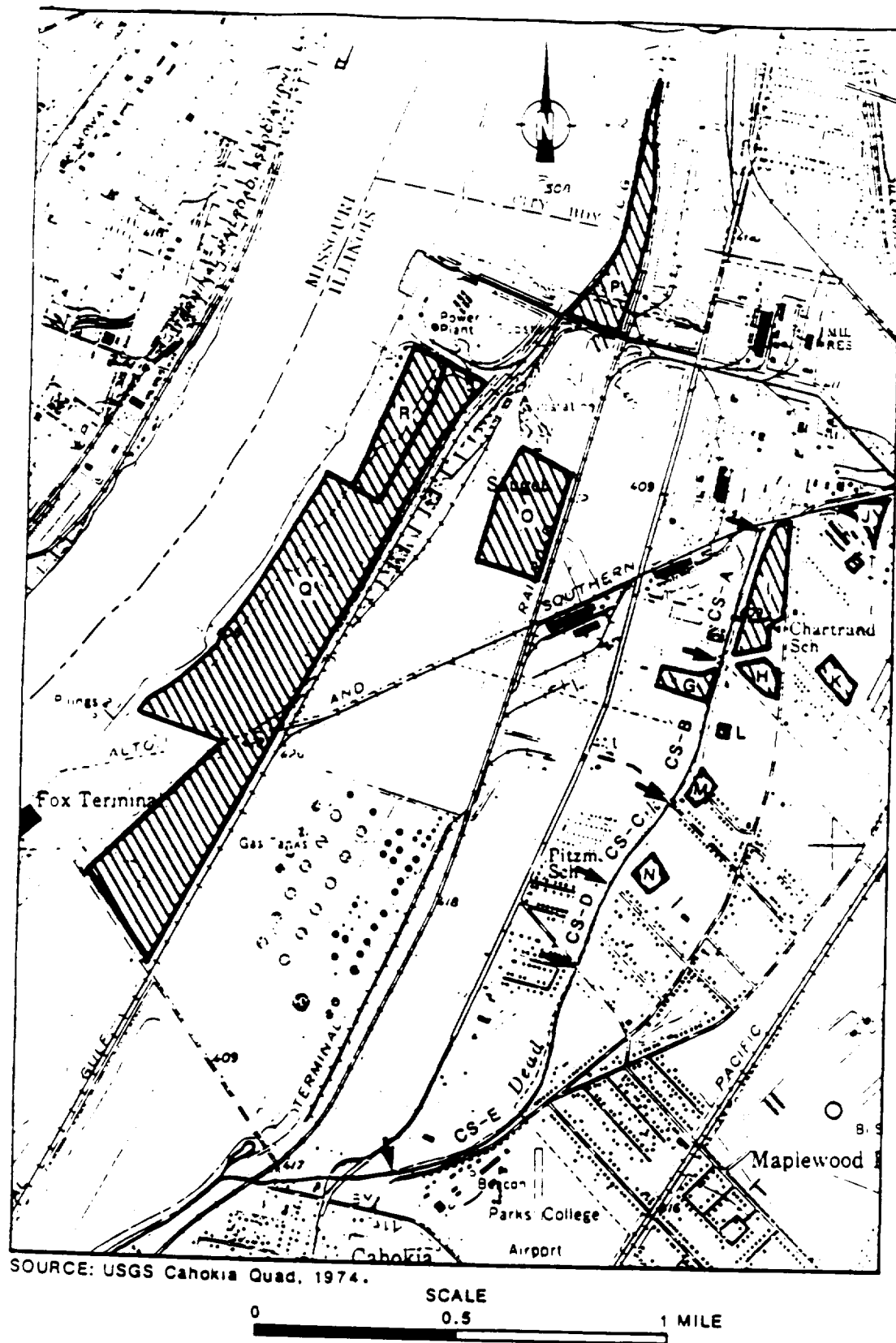
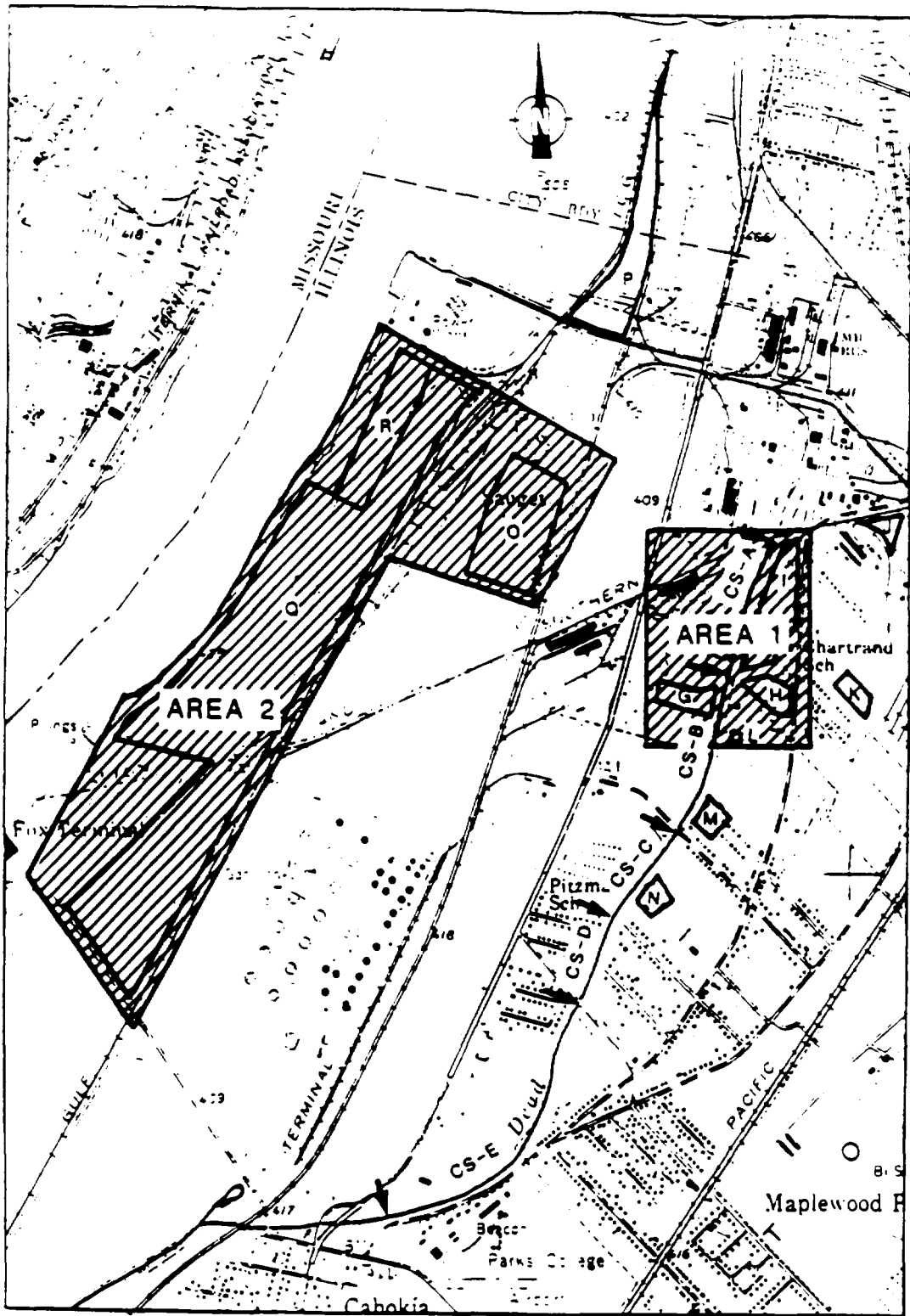


FIGURE 2-2 SITE REPORTING DESIGNATIONS FOR THE DEAD CREEK PROJECT



SOURCE: USGS Canokia Quad, 1974.

SCALE

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1 MILE

FIGURE 2-3 SITE GROUPINGS FOR THE DCP UNDER THE REVISED SCOPE OF WORK

The following is a brief description of the individual sites and Dead Creek:

Area 1 Sites

Site features for Area 1 sites and creek sectors are shown in Figure 2-4.

Site G. Site G is a former subsurface/surface disposal area which occupies approximately 4.5 acres. The site is located in Sauget and is bordered on the north by Queeny Avenue, on the east by Dead Creek, on the south by a cultivated field, and on the west by Wiese Engineering Company property.

The surface of Site G is littered with demolition debris and metal wastes. Two small pits are located in the northeast and east-central portions of the site. Oily and tar-like wastes, along with scattered corroded drums, are found in these areas. Additionally, 20 to 30 deteriorated drums are scattered along a ridge running east-west, near the southern perimeter of the site. The western portion of Site G contains a mounded area with several corroded drums protruding from the surface. A large depression is found immediately south of the mounded area. This depression receives surface runoff from a sizable area within the site. Exposed debris is also present over most of the site. In areas where wastes are not exposed, fly ash and cinder material has been used as cover. Presently, a chain-link fence surrounds Site G. The fence was constructed in May 1987 as a response action after high levels of organic contamination were detected in surficial soils.

Site H. Site H is a former subsurface disposal area covering approximately 5 acres. The site is located in Sauget immediately southwest of the intersection of Queeny Avenue and Falling Springs Road. The surface of Site H is an open field which has been covered, graded, and vegetated. Several depression areas, capable of retaining rainwater, are also evident across the site. Surface drainage is generally to the west; although certain localized drainage is toward the depressions. Waste material is not evident on the surface of the site. Access to Site H is not controlled.

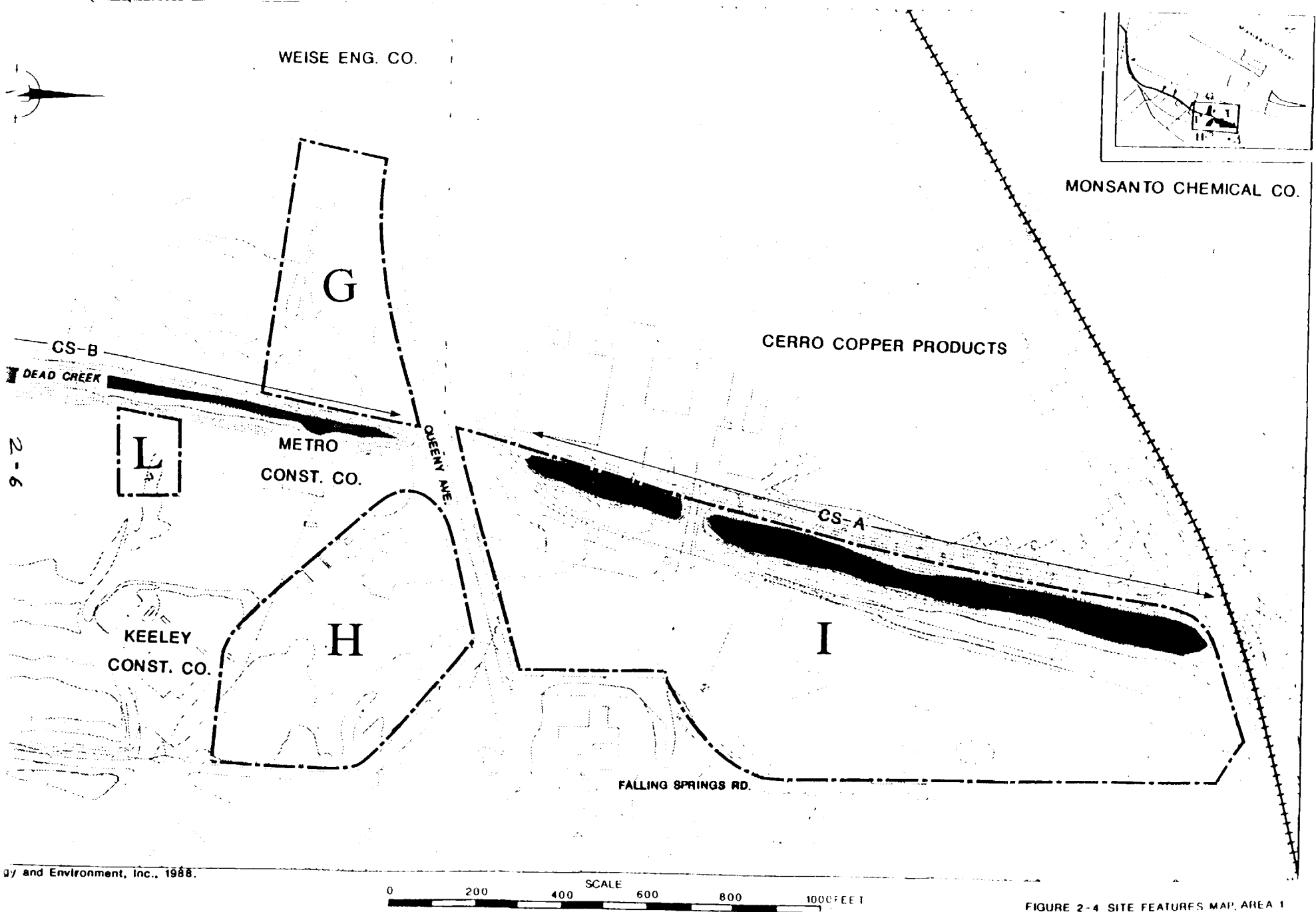


FIGURE 2-4 SITE FEATURES MAP, AREA 1

Site I. Site I, in Sauget, consists of approximately the eastern one-third of the Cerro Copper Products (Cerro) property. Cerro is a copper refining and tube manufacturing facility. Site I is approximately 55 acres in area and is a former sand and gravel pit which was subsequently filled with unknown wastes. Two holding ponds (Creek Sector A) which formerly served as headwaters for Dead Creek are located along the west side of Site I. The former gravel pit/fill area was covered and graded, and is presently used for equipment and scrap storage and truck trailer parking. No waste material or drums are evident on the surface of Site I. Access to the entire Cerro property is controlled by a chain-link fence and a 24-hour guard at the main entrance to the facility.

Site L. Site L is the former location of a surface impoundment used by a hazardous and special waste hauler to dispose of wash water from truck cleaning operations. The dimensions of the impoundment are approximately 70 feet by 150 feet. The impoundment was approximately 250 feet south of the present Metro Construction Equipment Company (Metro) building, and approximately 125 feet east of Dead Creek in Cahokia. The site is now covered with black cinders, and is used by Metro for equipment storage. Several rows of heavy construction equipment are presently stored on the site. No waste material is visible on the surface of Site L. Access to the area is not controlled.

Dead Creek Sectors A and B. Creek Sector A (CS-A) is on Cerro property in Sauget and is located immediately west of the former sand pit which constitutes Site I of the DCP. The creek in this area presently consists of two holding ponds which receive surface runoff and roof drainage from Cerro. According to Cerro officials, no process wastewater, cooling water, or other waste is discharged to the ponds. The water in CS-A is highly discolored and oily, as evidenced by staining along the creek banks. A culvert located at the south end of CS-A that extends under Queeny Avenue was blocked some time in the early 1970s to prevent flow to the remainder of the creek. Since CS-A lies entirely on Cerro property, access is as described above for Site I.

Creek Sector B (CS-B) is the portion of Dead Creek lying between Queeny Avenue and Judith Lane in Sauget and Cahokia. Three other sites in the DCP study area are located adjacent to CS-B, namely, Site G to the northwest, Site L to the northeast, and Site M to the southeast. All of these sites have been identified at one time or another as possible sources of pollution in CS-B. Presently, CS-B and Site M are encompassed by a chain-link fence which was installed by the USEPA in 1982. The banks of the creek are heavily vegetated, and debris is scattered throughout the northern one-half of CS-B. Culverts at Queeny Avenue and Judith Lane have been blocked, preventing any release of contaminants to the remainder of the creek. Water levels in the creek vary substantially, depending on rainfall, and during extended periods of low precipitation, the creek becomes a dry ditch.

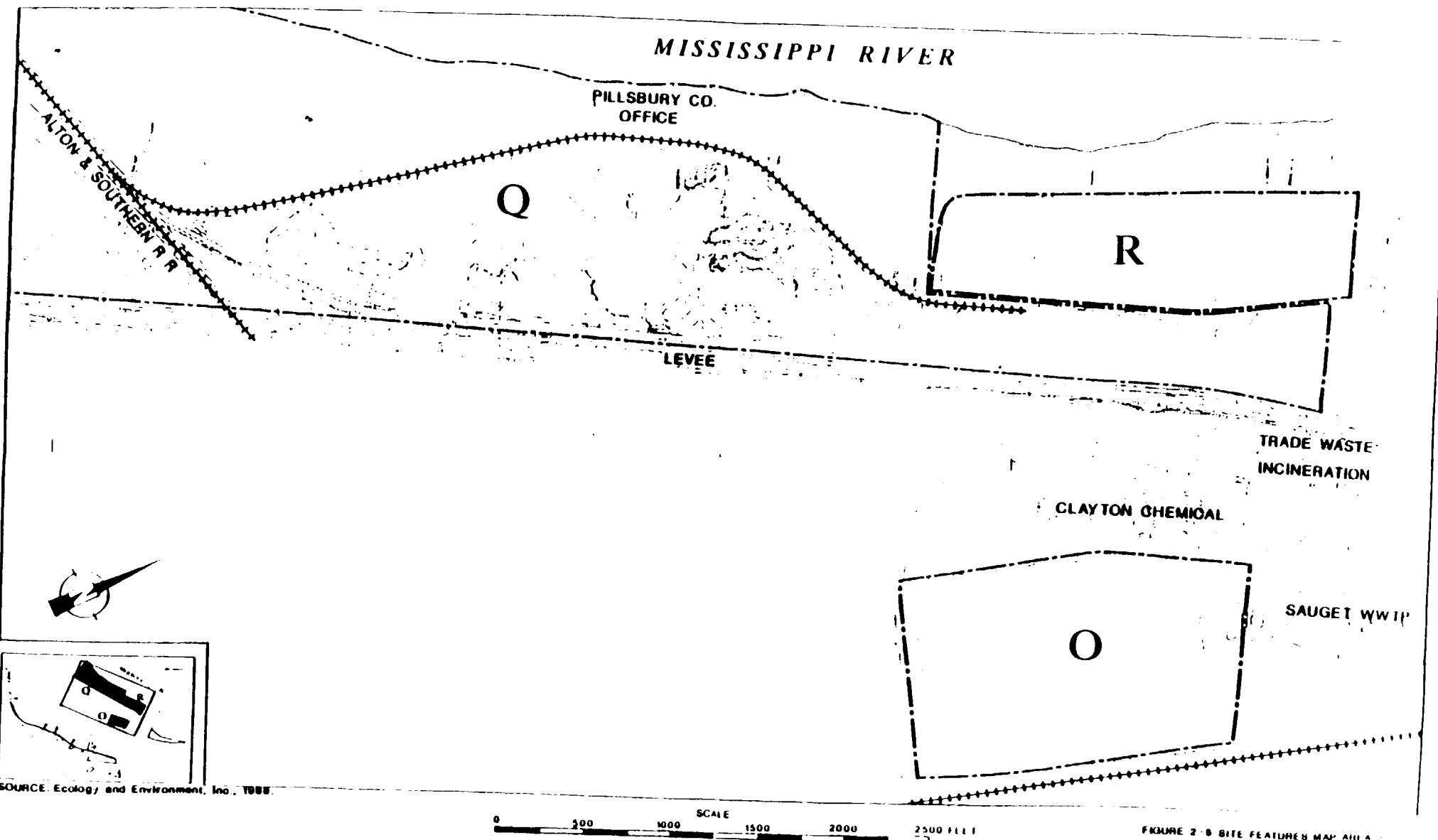
Area 2 Sites

Site features for Area 2 sites are shown in Figure 2-5.

Site 0. Site 0 contains four inactive sludge dewatering lagoons associated with the Sauget Waste Water Treatment Plant. The site covers approximately 45 acres in a heavily industrialized area located on Mobile Avenue in Sauget. The former sludge lagoons cover approximately 20 acres to the south of the treatment plant buildings. The former lagoons have been covered. An access road to the new American Bottoms Treatment Plant, located immediately southwest of the former lagoons, runs through the middle of the site. Although chain-link fencing surrounds most of the site, vehicular traffic on the access road is not restricted.

Two active industrial facilities, Clayton Chemical Company and Trade Waste Incineration, are located adjacent to the west boundary of Site 0. Clayton Chemical is a solvent recovery facility, and Trade Waste provides waste destruction services to area and other industries.

In addition to these facilities, a small area in the northern portion of Clayton Chemical property was formerly occupied by storage tanks owned by Bliss Waste Oil Company. These tanks were allegedly used to store waste oils and chemicals containing 2,3,7,8-tetrachlorinated dibenzo-p-dioxin (TCDD). One leaking underground storage tank was



removed from this area, and contaminated soil was excavated and disposed of off-site. A separate area of contamination was identified at Site Q in 1983. A coordinated sampling effort between IEPA and Envirodyne Engineers revealed high concentrations of TCDD and polychlorinated biphenyls (PCBs) in surficial soils in an area northwest of the former sludge lagoons. Contaminated soil and gravel was removed from the area, and is currently stored in an enclosed area on the treatment plant property.

Site Q. Site Q is an inactive waste disposal facility in Sauget and Cahokia, formerly operated by Sauget and Company. The site covers approximately 90 acres and is located on the east bank of the Mississippi River, on the river side of a United States Army Corps of Engineers (COE) flood control levee. The northern one-third of Site Q is situated immediately east of Site R. The majority of Site Q is presently occupied by the Pillsbury Company, which operates a coal and grain unloading and transfer facility on the property. Large mounds of coal and cinders are present in the northern one-half of the property. The southern portion of the site is presently unoccupied. Some random dumping of household-type waste is evident in this area. A railroad spur divides the site, running north from the Alton and Southern Railroad tracks to the northern one-third of the property, where it ends. Several ponds, including two in the east-central portion and two in the area south of the Alton and Southern Railroad tracks, also exist on the site. Vehicular access to Site Q is presently restricted by fencing in the northern portion of the site and by a 24-hour guard at the main gate. Pedestrian access to the site, however, is unrestricted in the southern portion of the site.

Site R. Site R, in Sauget, is the Sauget Toxic Dump (also known as the Krummrich Landfill), an inactive industrial waste landfill owned by the Monsanto Chemical Company (Monsanto) and used by Monsanto as a landfill between 1957 and 1977. Site R occupies approximately 36 acres and is located immediately west and north of Site Q. A Monsanto feedstock tank farm is located adjacent to the site on the northwest side, between the west border of Site R and the Mississippi. The site

is presently covered with a well-vegetated clay cap. Surface drainage flows to ditches around the perimeter of the site. The riverbank adjacent to the site is covered with rip-rap consisting of large rocks and boulders. This site has a long history of leachate flow into the Mississippi River. Access to Site R is restricted by a chain-link fence, and television cameras are used to monitor activity at the main gate. A second gate provides access through Site Q.

Peripheral Sites

Site J. Site J is in two segments on the Sterling Steel Foundry Property in Sauget in the eastern part of the DCP. It consists of two pits and a surface disposal area presently utilized by Sterling (see Figure 2-6). The surface disposal area, occupies approximately 5 acres in a roughly triangular area northeast of the plant buildings, south of the Alton and Southern Railroad, and west of a burned area. Casting sand, slag, and miscellaneous debris covers this entire area. A small pit contiguous to the triangular area, north of the main foundry building has been partially filled with casting sand and baghouse dust. No evidence of chemical waste disposal is apparent in this area. A larger pit is situated southeast of the plant buildings. This pit has been partially filled with casting sand and miscellaneous debris. The larger pit is approximately 25 feet deep, and there is water at the bottom of it. The entire Sterling property is bordered by a chain-link fence; however, the entrance gate is not locked or guarded.

Site K. Site K is a former sand pit identified through historical aerial photographs. The pit has been filled with unknown materials and covered with soil and gravel. The area has been graded to the surrounding topography. The site is presently unoccupied, covers 6 acres, and is located in Sauget north of a residential area on Queeny Avenue, and east of Falling Springs Road (see Figure 2-7). Several trailer homes and houses are located within 100 feet of the site. Access to Site K is not restricted.

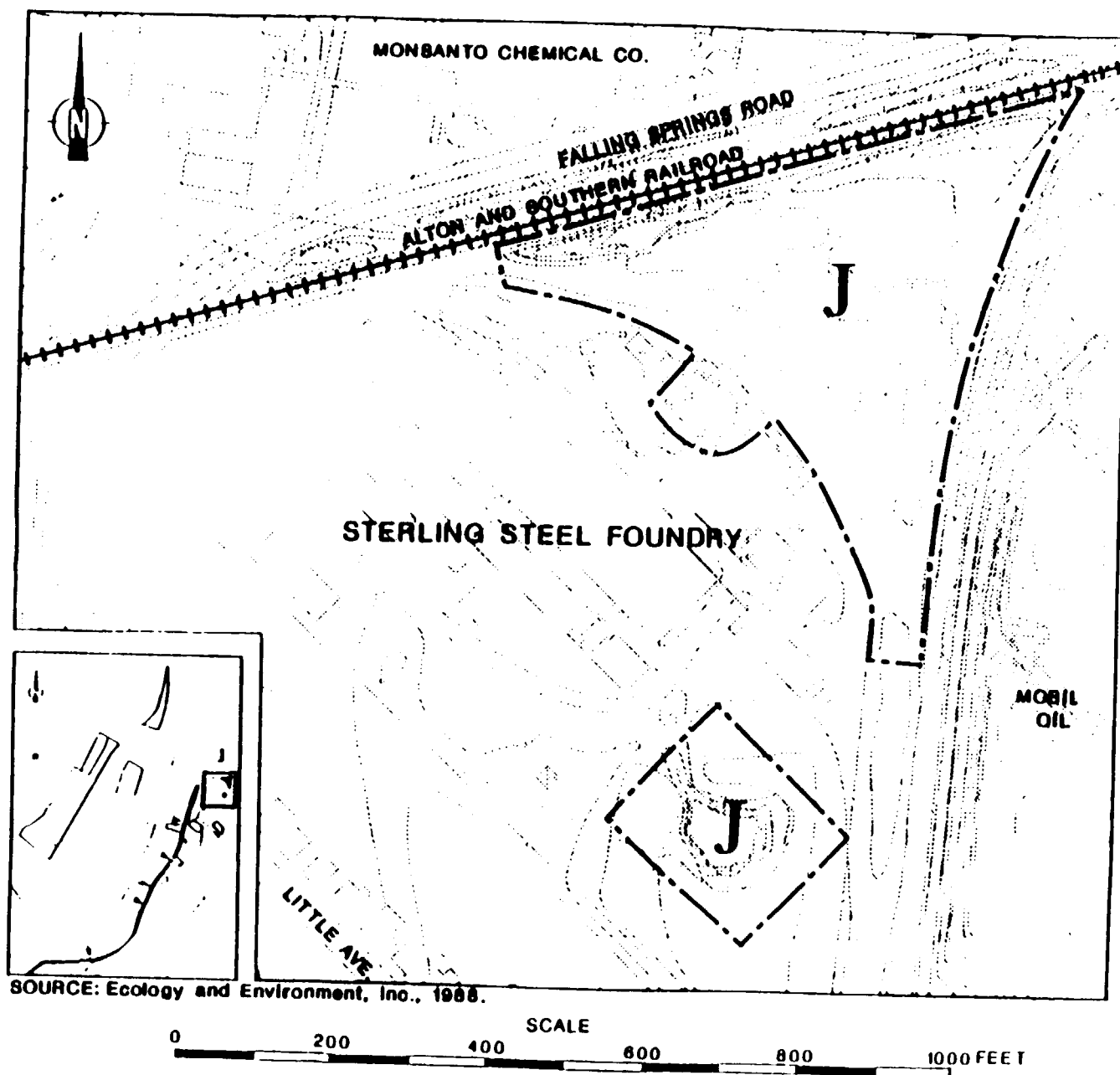
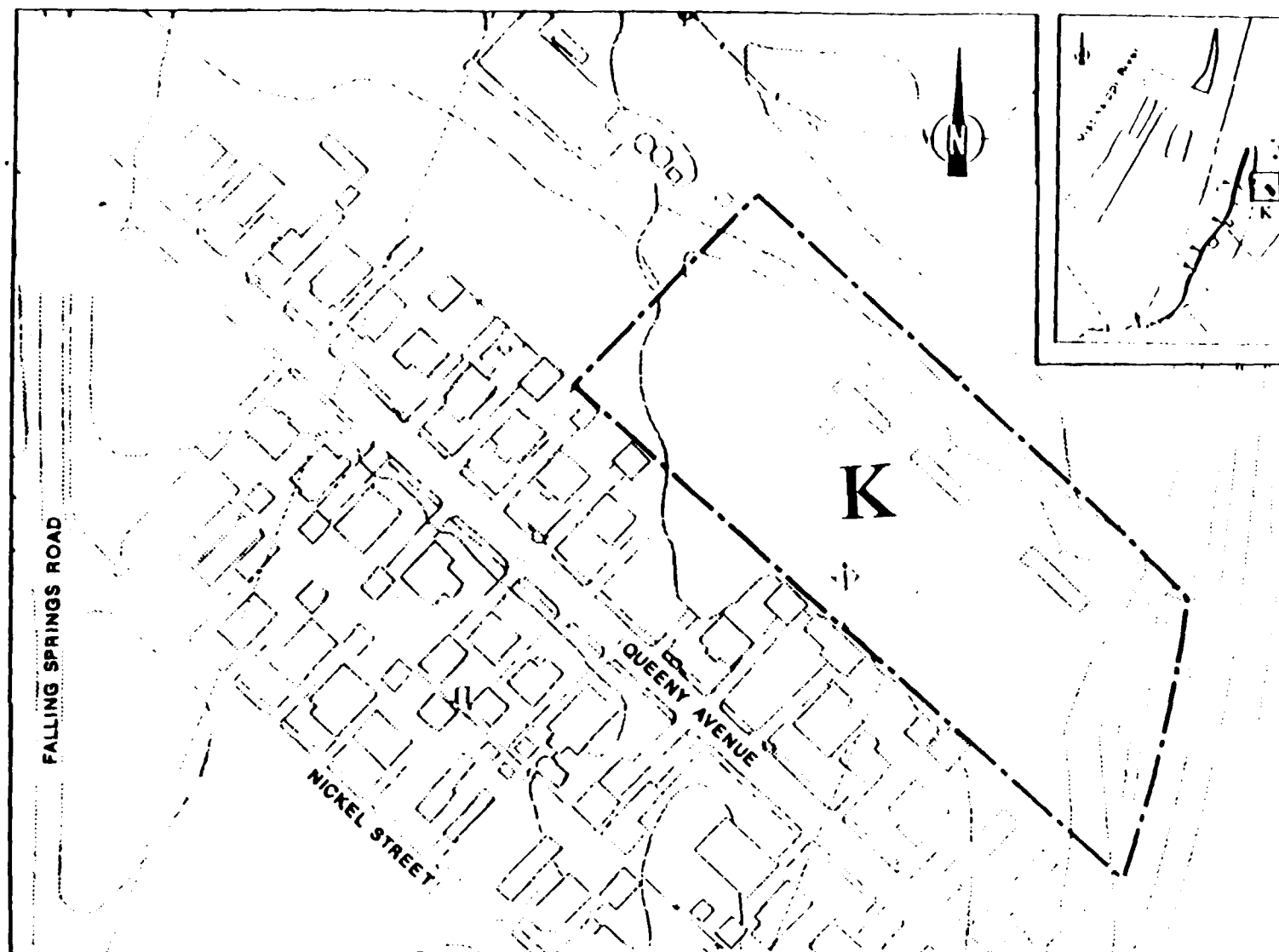


FIGURE 2-6 SITE FEATURES MAP, SITE J



SOURCE: Ecology and Environment, Inc., 1988.

SCALE
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FIGURE 2-7 SITE FEATURES MAP, SITE K

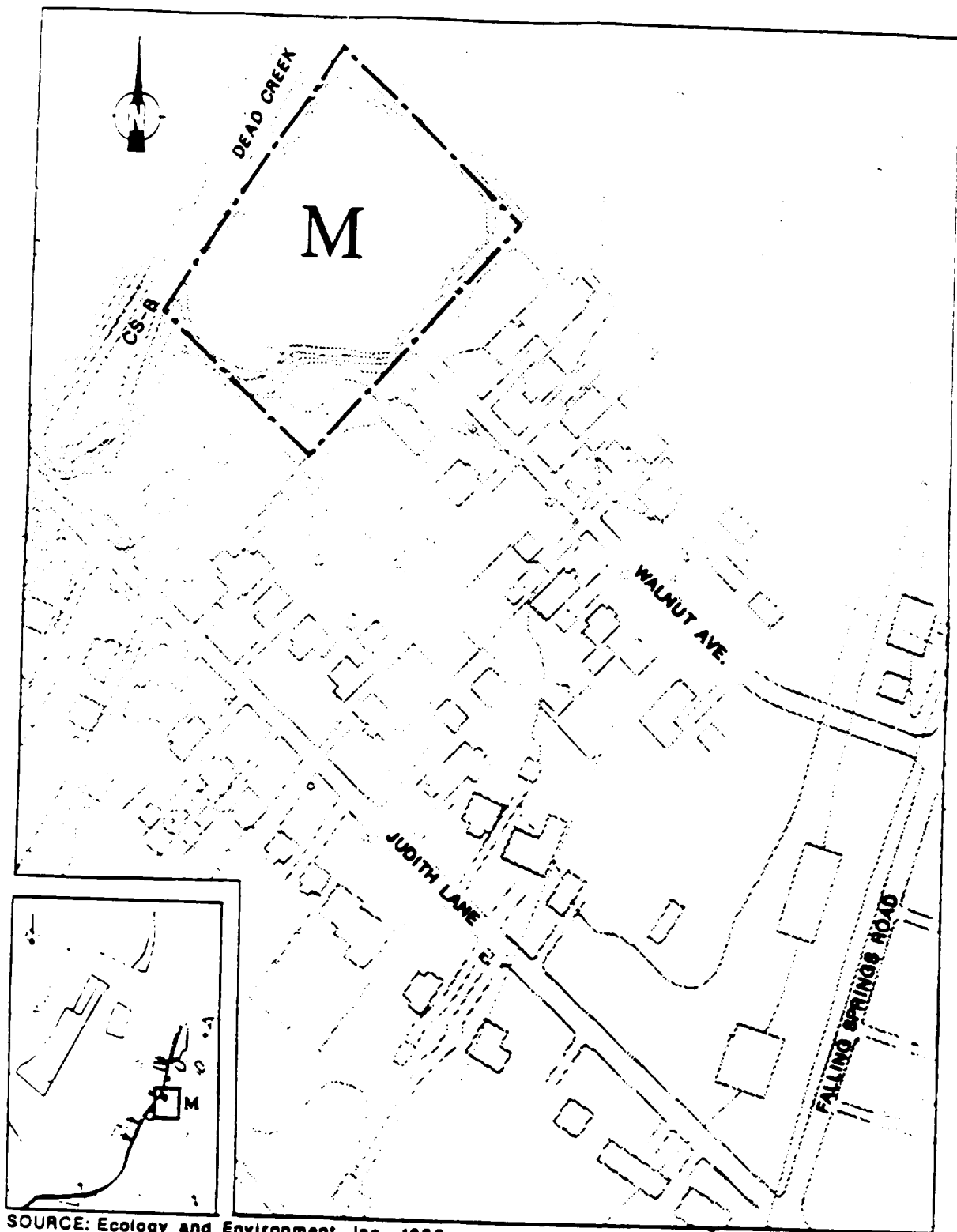
Site M. Site M, in Cahokia, is a former sand pit excavated by the H.H. Hall Construction Company in the mid- to late-1940s. It is located immediately east of Dead Creek, and approximately 300 feet north of Judith Lane (see Figure 2-8). The dimensions of the pit are approximately 275 by 350 feet, and the estimated depth is 40 feet. The pit is presently filled with water, although it remains unclear whether the water is a surface expression of the groundwater, or simply collected rainwater and drainage. Site M is connected to CS-B of Dead Creek by a drainage way, or cut-through, located in the southwest corner of the pit. This cut-through is approximately 8 feet wide, and allows flow between the creek and the pit. The east bank of the pit is strewn with miscellaneous trash and debris. Other than this material, no evidence of waste disposal is apparent in the pit.

Presently, Site M is enclosed by a chain-link fence, which also encompasses CS-B. A small residential area is located just east of the pit on Walnut Street, which earlier served as an access road to Site M. The pit was excavated prior to any residential development on this street.

Site N. Site N is an excavated area in the southwest corner of an inactive construction yard owned by the H.H. Hall Construction Company of East St. Louis (see Figure 2-9). The site is 4 acres in area and is bordered on the northwest by Dead Creek. The excavated area has been partially filled with construction and demolition debris, but the area remains below the surrounding topography.

The Hall property is presently used only for equipment storage. Access to the Hall property is restricted by a chain-link fence with a padlocked gate.

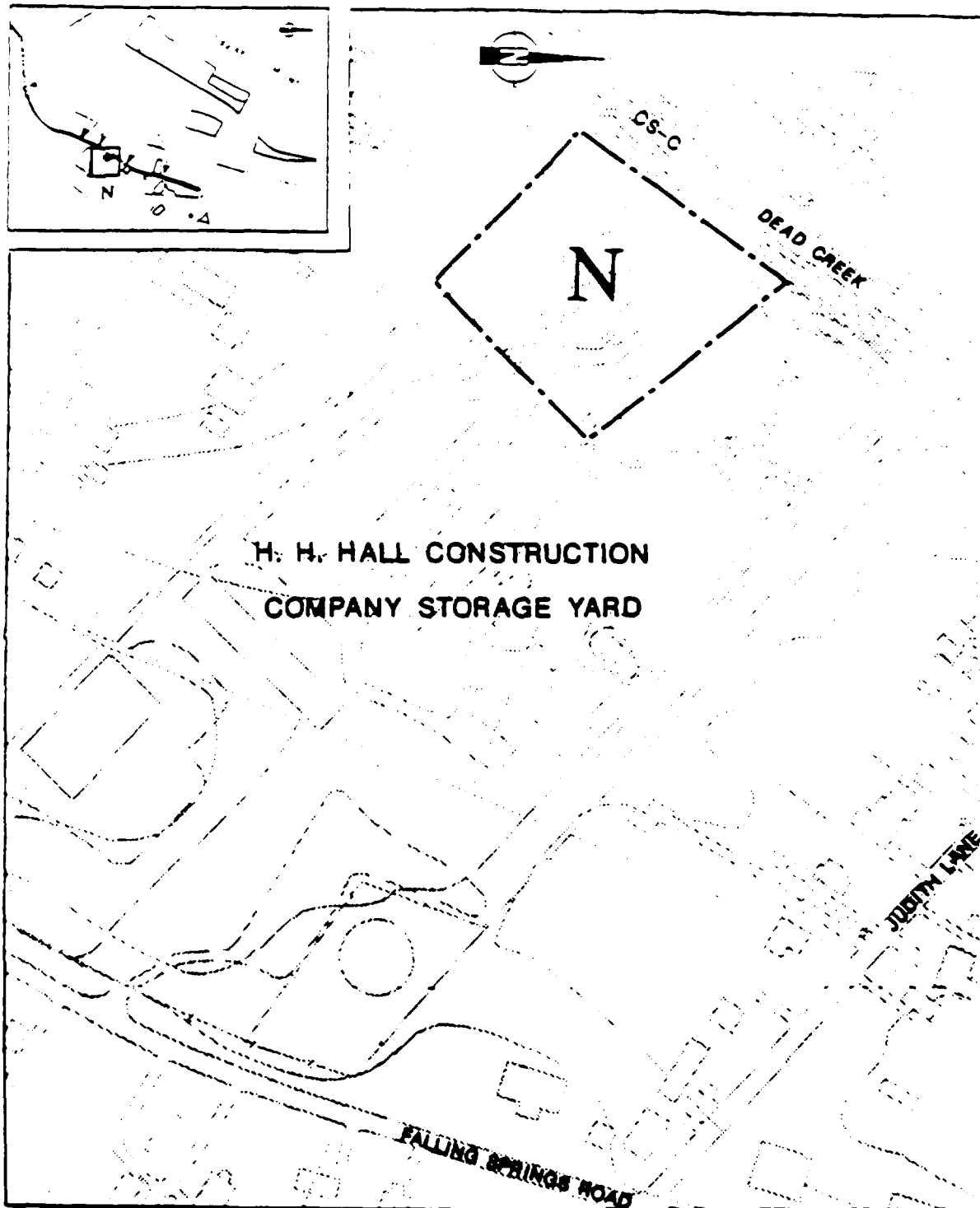
Site P. Site P is an inactive, IEPA-permitted landfill operated by Sauguet and Company covering approximately 20 acres in the northern part of the DCP in Sauguet (see Figure 2-10). The site is bordered on the west by Illinois Central Gulf Railroad tracks; on the south by Monsanto Avenue; and on the east by the Terminal Railroad Association railroad tracks. The two railroads converge at the north end of the site.



SOURCE: Ecology and Environment, Inc., 1988.

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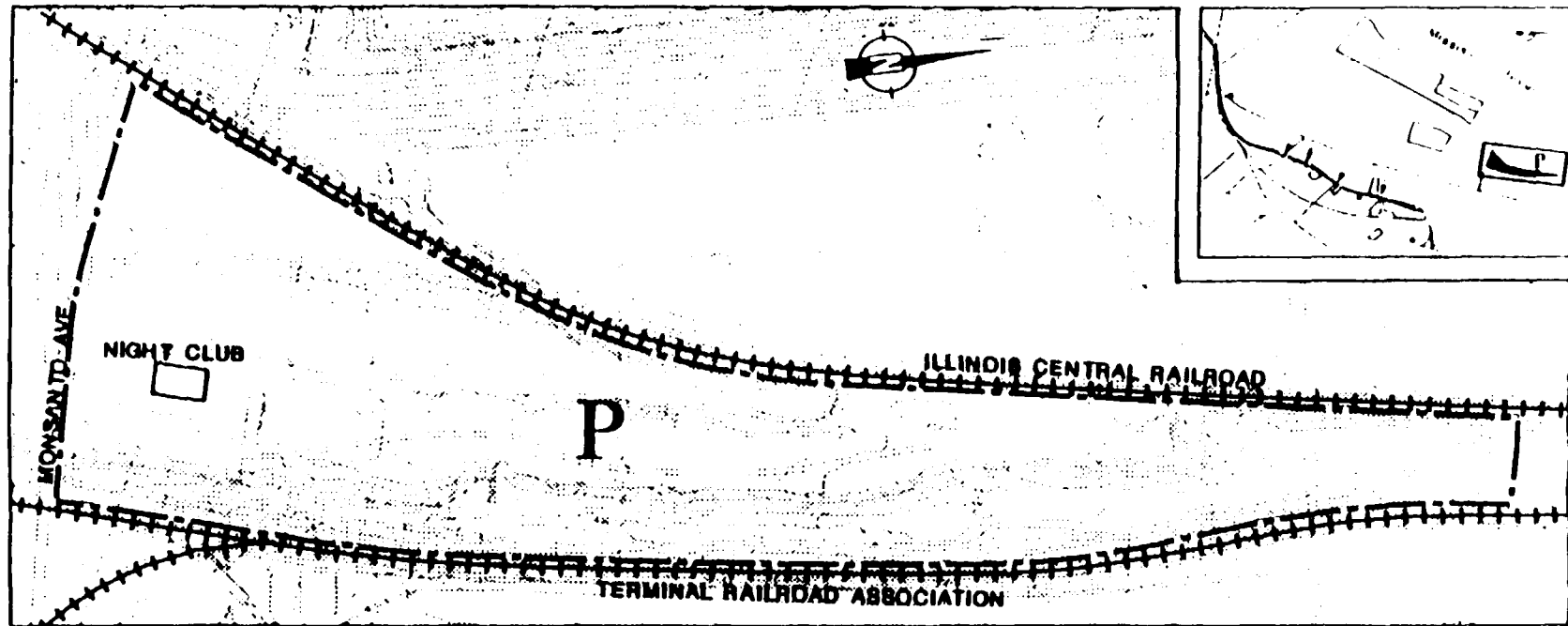
FIGURE 2-8 SITE FEATURES MAP, SITE M



SOURCE: Ecology and Environment, Inc., 1988.

SCALE
0 100 200 300 400 500 FEET

FIGURE 2-9 SITE FEATURES MAP, SITE N



SOURCE: Ecology and Environment, Inc., 1988.

SCALE
0 200 400 600 800 1000 FEET

FIGURE 2-10 SITE FEATURES MAP, SITE P

Site P is characterized by steep sloping landfill sides along its east and south-central portions. The majority of the site is covered with cinders. Deep erosional channels are prevalent along the slopes. The south-central portion of the site was not landfilled because of the presence of a potable water line in this area. A nightclub and asphalt-covered parking lot presently occupy approximately 3 acres in the southeast corner of the site. Access to the site is not restricted.

Dead Creek Sectors C through F. Creek Sectors C through F include the entire length of Dead Creek south of Judith Lane. This portion of the creek flows south-southwest through the Village of Cahokia prior to discharging into the Prairie DuPont Floodway (see Figure 2-11). The floodway subsequently discharges into the Cahokia Chute of the Mississippi River. The creek is wider in these sectors than in Sectors A and B, and the banks are not as heavily vegetated as along CS-B. In the southern portion of CS-D, near Parks College, the creek runs underground through a corrugated pipe. The creek resurfaces briefly at the intersection of Illinois Route 157 and Falling Springs Road. Downstream of this point, the creek runs west through a series of culverts prior to draining into a wetland area west of Illinois Route 3.

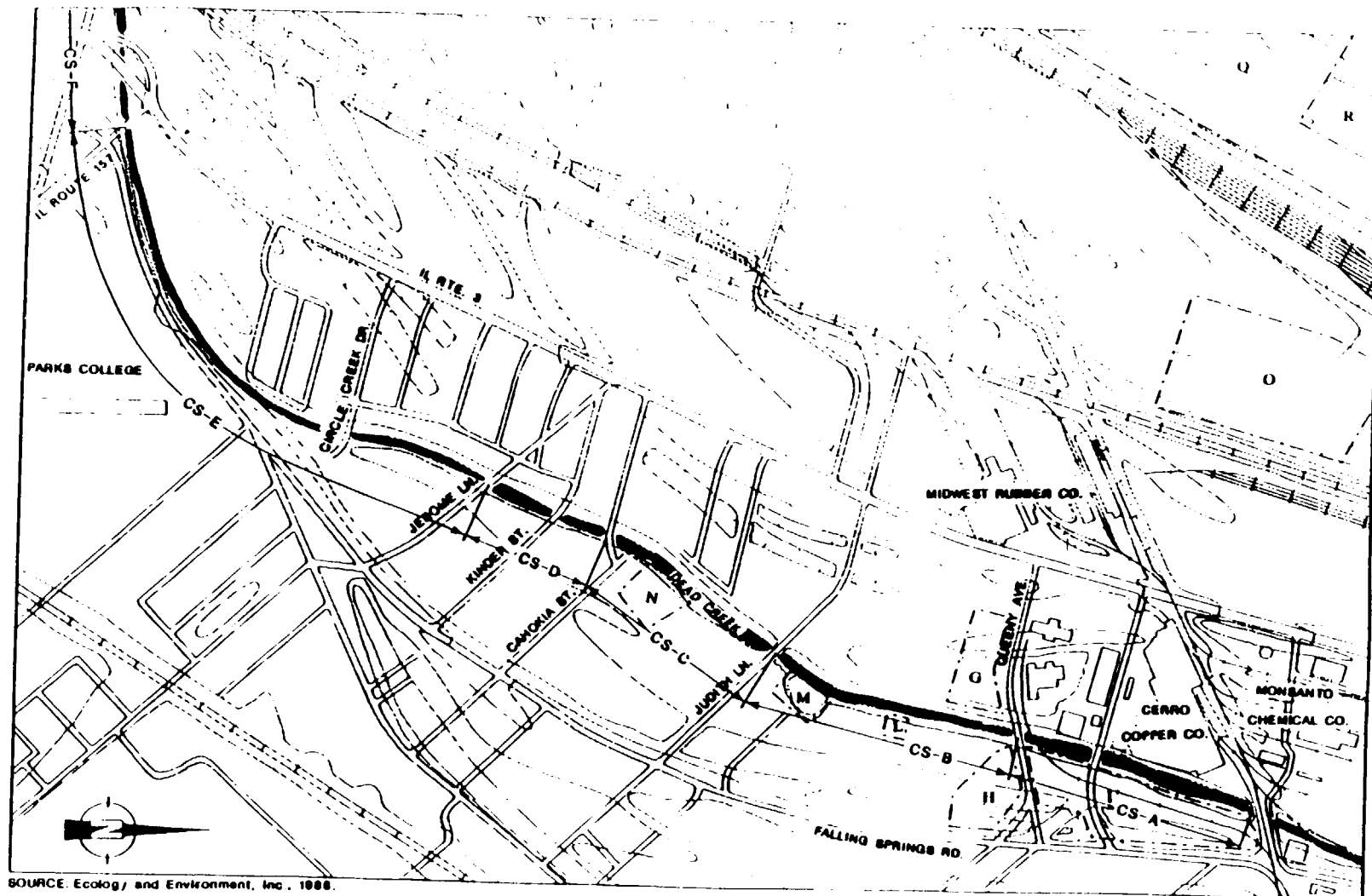
Creek Sectors C through F are delineated as follows: CS-C, Judith Lane to Cahokia Street; CS-D, Cahokia Street to Jerome Street; CS-E, Jerome Street to the intersection of Illinois Routes 3 and 157; and CS-F, from this intersection to the discharge point in Old Prairie DuPont Creek. Access to Creek Sectors C through F is unrestricted, and children have been observed playing in and around the creek on several occasions.

2.2 SITE GEOGRAPHY

2.2.1 Physiography

2.2.1.1 Area Topography

The DCP study area is situated in the far southwest portion of the Springfield Plain within the Till Plains Section of the Central Lowland Province (Leighton et al. 1948) of Illinois (see Figure 2-12). The Springfield Plain is basically a flat till plain consisting of Illinoian drift. The western boundary of the till plain is marked by morainic and



SOURCE: Ecology and Environment, Inc., 1988.

0 1000 2000 3000 4000 5000 FEET
SCALE

FIGURE 2 II SITE FEATURES MAP, IN ADDITION

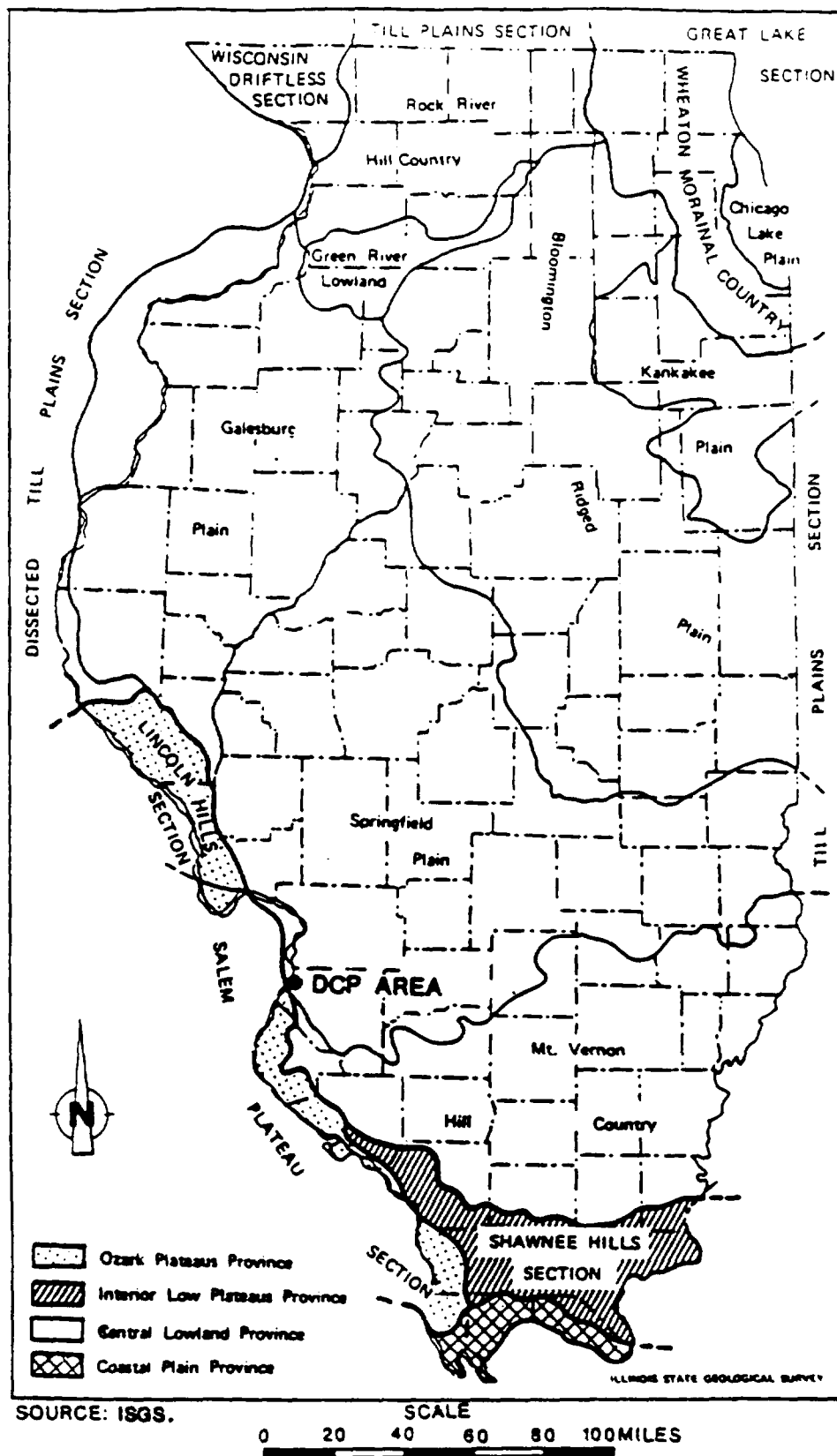


FIGURE 2-12 PHYSIOGRAPHIC DIVISIONS OF ILLINOIS

flood plain features, including broad and flat swampy areas, terraces, curved ridges and swales, and crescent-shaped ox-bow lakes.

The project area lies in the floodplain, or valley bottom, of the Mississippi River in an area known as the American Bottoms. For the most part the topography consists, of nearly flat bottomland, although many irregularities exist locally across the site areas. Topography in the site area is controlled by structural features of the bedrock which resulted from glacial and fluvial events. Generally, the land surface in undisturbed areas slopes from north to south, and from the east toward the river. This trend, however, is not followed in the immediate vicinity of the DCP study area. Elevations at Area 1 sites range from 410 to 400 feet above mean sea level (MSL), while elevations at Area 2 sites range from approximately 425 to 400 feet above MSL. Little topographic relief is exhibited across individual sites, with the exceptions of Sites G and P. The Mississippi river floodplain is defined by steep-rising bluffs to the east and west of the river. These bluffs rise abruptly 150 to 200 feet above the valley bottom, and are located approximately 5 miles east of the DCP study area.

2.2.1.2 Surface Drainage

Surface drainage in the project area is typically toward the Mississippi River (Area 2 sites) or toward Dead Creek (Area 1 sites). However, significant site-specific drainage patterns are present. A brief description of surface drainage for individual sites is given below.

Area 1 Sites

Site G. Drainage at Site G is generally east toward CS-B. A large depression exists in the south-central portion of the site. Surface runoff in this area flows toward the depression.

Site H. Drainage at Site H is typically to the west toward CS-B. Several small depressions capable of retaining rainwater, are scattered across the site. Precipitation in these areas infiltrates the ground surface rather than draining from the site.

Site I. Drainage is generally to the west toward the two holding ponds which make up CS-A. CS-A also receives surface and roof drainage from the entire Cerro plant area located west of CS-A. This drainage flows through a series of storm sewers and effluent pipes. A large depression exists in the northern portion of Site I. Precipitation runoff in this area flows toward the depression.

Site L. Site L is a former subsurface impoundment which has subsequently been covered with highly permeable material (cinders). Runoff from the surface, although inhibited by the permeable nature of the cinders, flows toward CS-B.

Area 2 Sites

Site O. Surface drainage of Site O is generally to the west toward the Mississippi River. Drainage to the river, however, is impeded by intervening topographic features, including the levee. Site O has been clay-capped. Surface runoff flows to low areas around the site or to storm sewers.

Site Q. The majority of Site Q is covered with highly permeable material which allows rapid infiltration of most precipitation. The limited surface runoff is primarily directed toward the river. Two large ponds are located in the east-central portion of the site. Surface runoff in this area is directed toward the ponds. Site Q is located on the river side of the COE flood control levee. The southern portion of the site has experienced periodic flooding over the last 10 years, most notably in 1977 and 1987.

Site R. Site R is presently covered with a clay cap. Surface runoff typically flows toward the river. Two small drainage channels along the western boundary of the site direct flow to the river.

Peripheral Sites

Site J. Surface runoff from Site J generally flows to a ditch along the west side of the site. This ditch eventually drains into a storm sewer. However, Site J is covered with highly permeable material, and several depressions are scattered across the site, creating local drainage patterns in the depression areas.

Site K. Surface drainage from Site K is toward low areas situated north and east of the site. Site K has very little topographic relief, and precipitation commonly ponds on the site or infiltrates the surface.

Site M. Site M receives surface runoff from a small residential area located east and south of the site. Water in Site M eventually drains into CS-B through a cut-through located in the southwest corner of the site.

Site N. Because the excavation which constitutes Site N only partially filled, it receives runoff from the surrounding area. The creek bank in this area (CS-B) is approximately 10 feet higher than the lowest point in the excavation.

Site P. A wide range of topographic relief is exhibited across the entire surface of Site P. The east and west boundaries of the site are marked by sharply sloping sidewalls which rise 30 to 40 feet above the foot of the landfill. A valley is found in the west-central portion of the site. This area was not landfilled due to the presence of a potable water line in the area. All of the landfill sidewalls are marked by deep, broad erosion gulleys, indicating uncontrolled runoff from the landfill to surrounding areas.

Dead Creek

Dead Creek serves as a surface water conduit for much of the Sauget and Cahokia area. The creek runs south and southwest through these towns to an outlet point in the old Prairie DuPont Creek floodway, located south of Cahokia. The floodway in turn discharges to the

Cahokia Chute of the Mississippi River. The total distance from Judith Lane to the ultimate discharge point into the Mississippi River is approximately 4.2 stream miles.

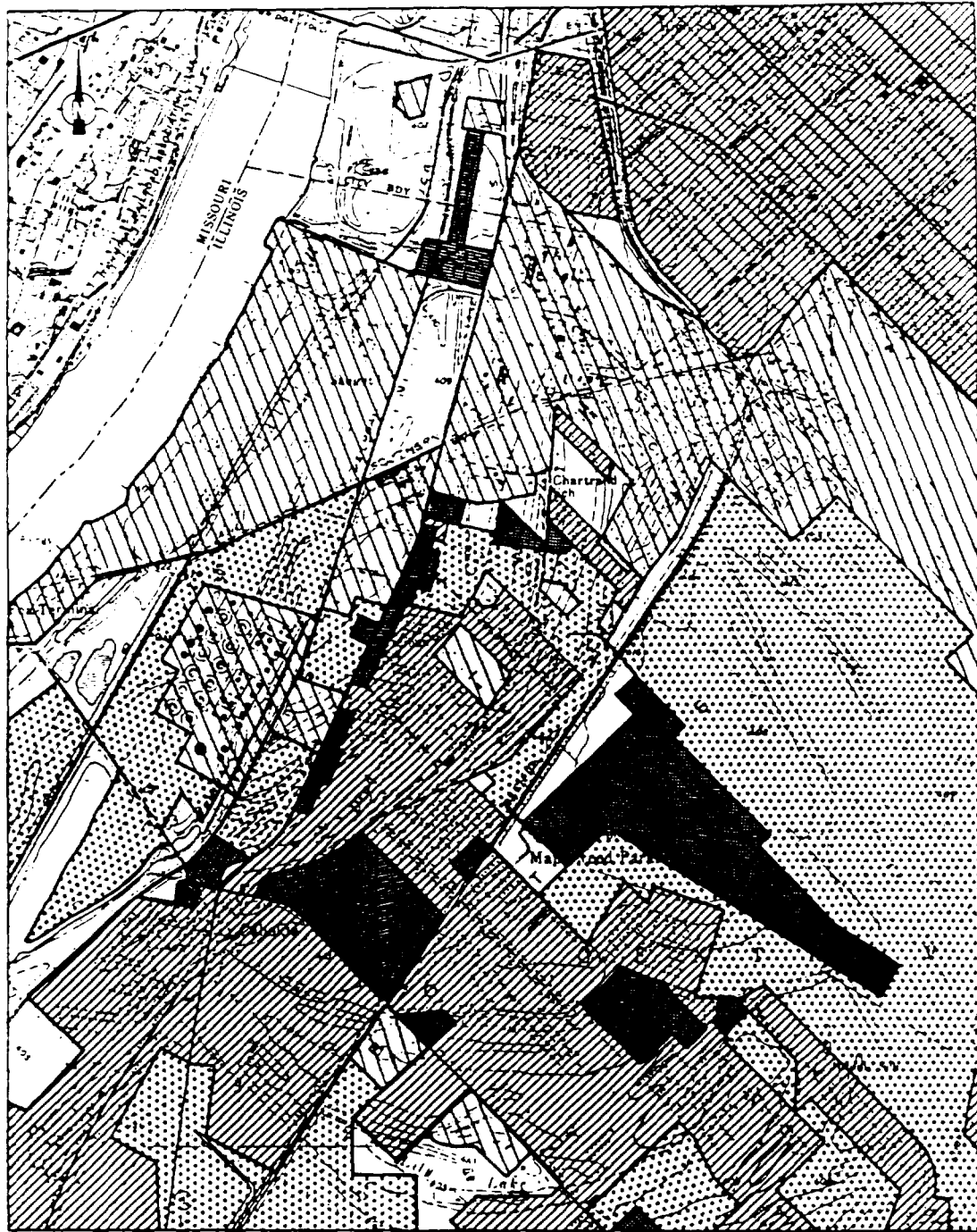
As discussed previously, CS-A is isolated from the remainder of Dead Creek because the culvert under Queeny Avenue has been blocked with concrete. CS-A drains to an interceptor at the north end of the Cerro property. Water from this interceptor is carried to the Sauget Treatment Waste Water Treatment Plant. The culvert is partially blocked at the south end of CS-B, and flow from this sector to the remainder of the creek is restricted. Although the degree of this restriction has not been determined, it is known that water does not usually flow through this culvert.

2.2.2 Land Use

A wide variety of land utilization is present (see Figure 2-13). The primary land use in the town of Sauget is industrial, with over 50% of the land used for this purpose. Small residential, commercial, and agricultural properties are also interspersed throughout the town. Land use in Cahokia is residential, commercial, and agricultural. Significant land use features, in relation to individual project sites, will be discussed below.

Land surrounding the Area 1 project sites is used for several purposes. A small residential area is located immediately east of Sites H and I, across Falling Springs Road. The nearest residence is approximately 200 feet from these sites. The Sauget Village Hall is also located on top of, or adjacent to, Site I (the exact boundary of the former excavation in relation to the village hall is unclear on the aerial photographs). South of Sites G and L are two small cultivated fields, which are used primarily for soybean production. These fields separate the sites from a residential area in the northern portion of Cahokia. Several small commercial properties are also found in the immediate vicinity of Area 1 sites.

Land surrounding the Area 2 project sites is used mainly for industrial purposes. Several commercial enterprises are located northeast of these sites, near the intersection of Illinois Route 3 and Monsanto Avenue. The nearest residential area to the Area 2 sites is



SOURCE: Ecology and Environment, Inc., 1988.

0 1 2 3 4 5 MILES

LEGEND






	RESIDENTIAL		INDUSTRIAL
	AGRICULTURAL		OTHER OR UNUSED
	COMMERCIAL		

FIGURE 2-13 LAND USE IN THE DCP AREA

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located approximately 0.5 mile to the southeast. An abandoned power plant is situated directly north of Sites Q and R, and an oil company tank farm is located east of the southern portion of Site Q. The presently operating Sauget Waste Water Treatment Plant, Trade Waste Incineration, and Clayton Chemical are also near Site O.

Most of the peripheral sites in the DCP study area are located in relatively close proximity to residential areas. Site J is located approximately 1,500 feet from a residential/commercial area in the city of East St. Louis. Site K is located adjacent to a small residential area in Sauget, as are Sites M and N. A commercial enterprise is located on top of a landfilled area at Site P, and other commercial properties are located immediately east of the site.

The entire population of the villages of Sauget and Cahokia is located within a 3-mile radius of the Area 1 sites. According to 1980 U.S. Census figures, the populations of these towns are 205 and 18,904, respectively. Portions of Centreville (pop. 9,747); Alorton (2,237); East St. Louis (55,200); and St. Louis (453,085), are also located within 3 miles of the project sites. Assuming an evenly distributed population for the aforementioned towns and cities, approximately 6,000 people live within 1 mile of the DCP sites. According to the Illinois Department of Commerce and Community Affairs (1988), approximately 3,200 people are employed by industries within 1 mile of the Area 1 sites. The city of St. Louis is located approximately 0.25 mile west of Site R, across the Mississippi River.

2.2.3 Climate

The climate in the DCP area is generally described as continental, with hot, humid summers and mild winters, punctuated by extremely cold periods of short duration. The site area is located in a major frontal convergence zone where warm, moist air from the Gulf of Mexico meets cold, dry air from Canada. This convergence zone produces a variety of rapid changes in weather conditions.

The 80-year average precipitation is 35.4 inches per year (SIMPRC 1983), although the yearly average over the last 25 years has increased slightly to 39.5 inches per year. June is normally the wettest month, with an average of 4.3 inches of rain. Much of the summer rainfall is

produced by thunderstorms, which are also responsible for the unusually heavy rains which periodically cause isolated flooding. Rainstorms which produce 1 to 2 inches of precipitation are common. Relative humidity typically ranges between 50 and 60% during the summer. Snow can occur in any and all months from November through April. Annual snowfall averages 17 inches.

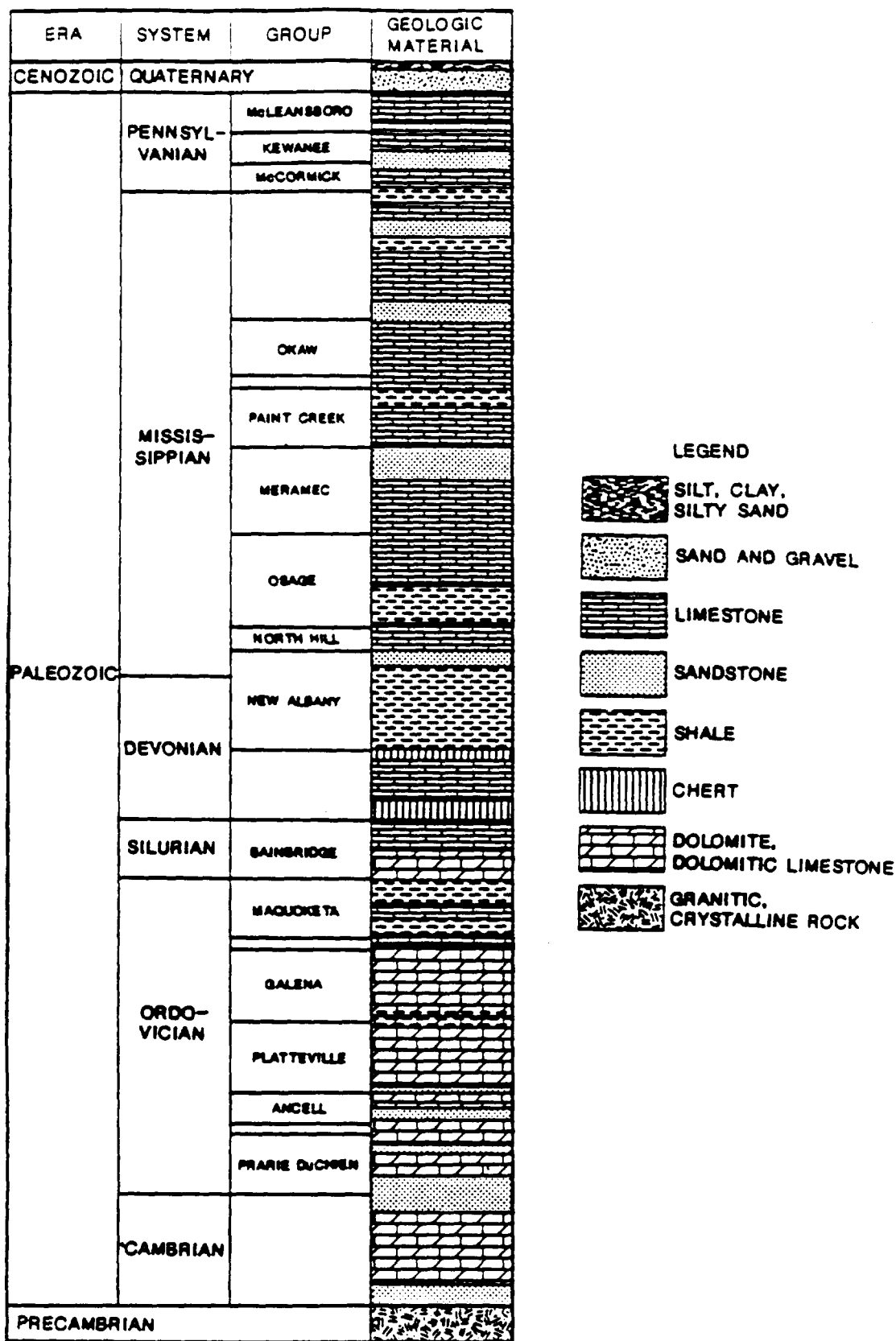
The regional average annual temperature is 56° F, with a January mean of 32° F and a July mean of 79° F. Periodic polar air fronts move through the area during the winter, producing lows of -10 to -15° F. July and August are typically hot and humid, producing temperatures above 90° F on an average of 22 days per year. Temperatures in excess of 100° F generally occur for short periods of 3 to 5 days.

Wind direction is typically from the northeast during the winter months and from the south to southwest during the summer. The mean annual velocity is 9.3 mph (U.S. Department of Commerce 1968).

2.3 REGIONAL GEOLOGY

The geologic formations present in the DCP area consist of unconsolidated alluvium and glacial outwash, which are underlain by Mississippian and other bedrock layers. These bedrock layers are underlain by basement granitic crystalline rock. The geologic formation sequence for south-central Illinois is presented in Figure 2-14. The study area, the American Bottoms, and the Mississippi River channels are all located in a broad, deeply cut bedrock valley. The bedrock valley is delineated by bluff lines on both sides. Based upon available data, the bedrock valley has steep walls along the bluffs while the valley bottom slopes gently toward the middle of the valley.

Within the bedrock valley, the Mississippi River has provided the primary mechanisms controlling the recent formation of geology and hydrogeology. Bergstrom et al. (1956) suggest that the bedrock valley is pre-glacial in nature; however, William et al. (1970) conclude that insufficient data exist to suggest a pre-glacial valley structure for the Mississippi River. Nevertheless, glaciation did significantly modify and redesign the Mississippi River and its valley through both glacial and interglacial periods. These changes occurred as glacial wasting caused massive amounts of meltwater to be directed generally



SOURCE: ISGS, 1971

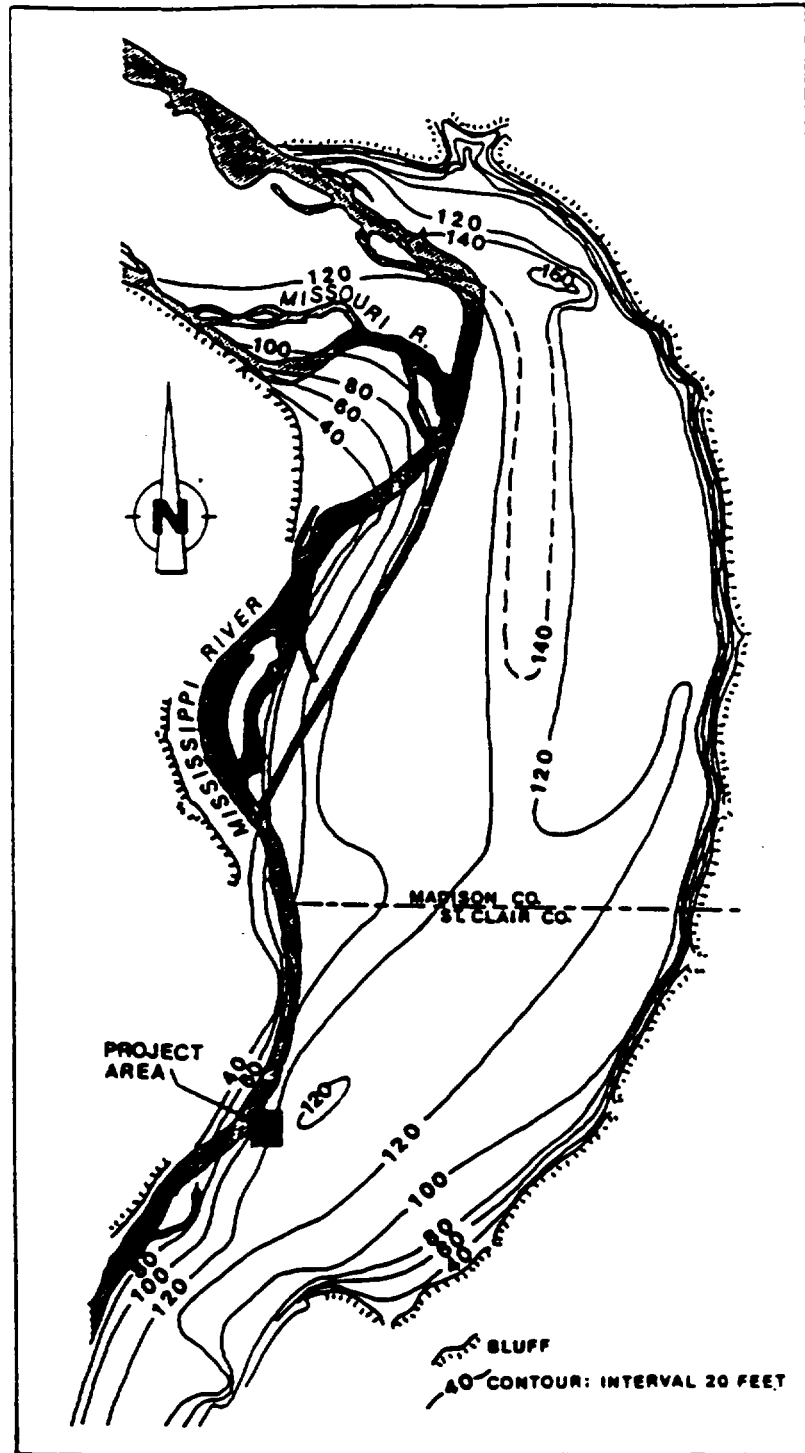
FIGURE 2-14 GENERALIZED GEOLOGIC COLUMN FOR SOUTH-CENTRAL ILLINOIS

southward through and around bedrock and ice contacts, ultimately discharging into the Gulf of Mexico. Through geologic history, a wide and deep valley (2 to 8 miles across and up to 170 feet deep) has been carved into the predominantly soft sedimentary bedrock underlying the river (Bergstrom et al. 1956). Changes in stream flow, direction, and sediment load have caused this valley to fill with secondary alluvial sediments. These constantly changing parameters have resulted in the river continuously picking up and depositing (and cutting and filling) its sediment base, thereby directing and redirecting the river and its channels through time.

The unconsolidated valley fill, present in the bedrock valley, ranges in thickness from approximately 70 to 120 feet in the study area. The thickness of the valley fill in the region of the study area is depicted in Figure 2-15. A cross-section of the valley fill in the vicinity of the study area is presented in Figure 2-16.

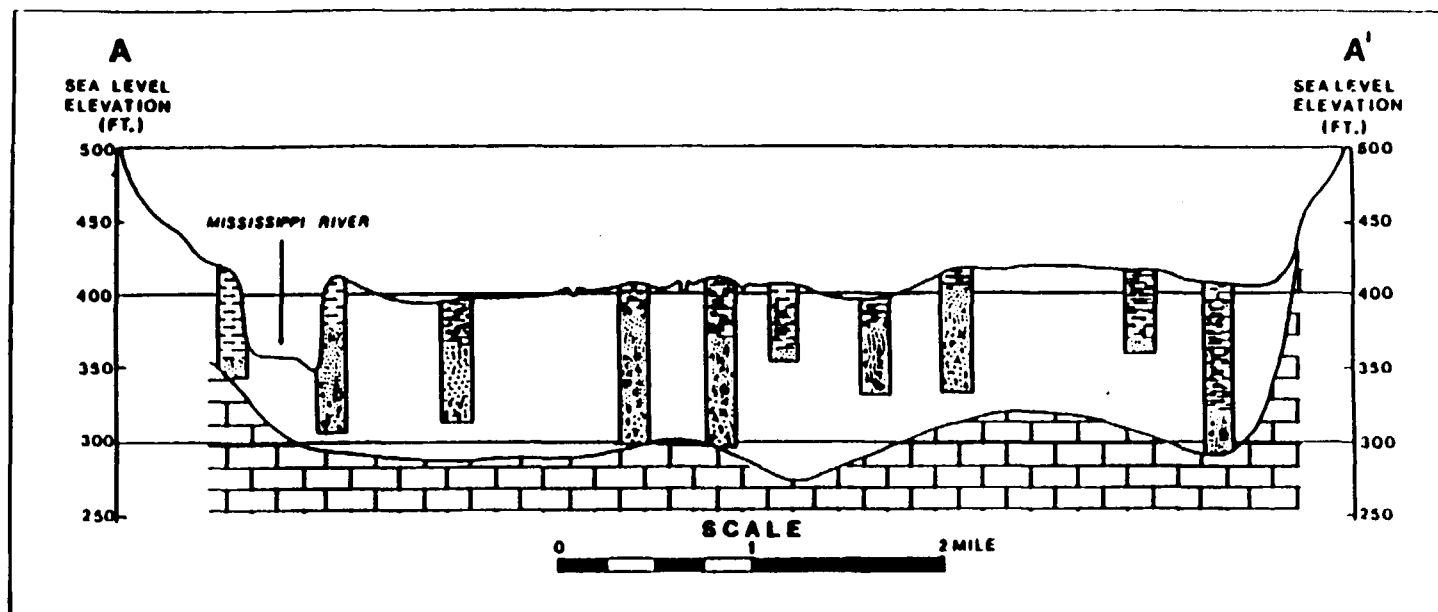
The valley fill deposits are typically composed of two main formations which may extend as deep as 120 feet in the DCP area. The Cahokia Alluvium, the uppermost formation, is composed predominantly of silt, clay, and fine sand deposits, generally indicative of an aggrading environment. These deposits were laid down as flood events of the Mississippi River, eolian activity, bank slumping, erosion, and/or slugs of material deposited directly by tributary streams. This formation has been frequently reworked by the Mississippi River and typically consists of coarser material intertongued with finer-grained deposits. As such, these deposits are variable in thickness (ranging from 15 to 30 feet). Larger expressions of tributary deposits may form thicker alluvial fans where high energy streams dissipated and dropped their sediment load.

The second major formation of the floodplain setting is the Mackinaw Member of the Henry Formation. This formation underlies the Cahokia Alluvium, and is composed of sand and gravel from glacial outwash. Within the study area, this material rests directly on the bedrock surface and can be highly variable in thickness (70 to 100 feet), due to the fluvial processes which formed it. This formation typically contains portions which are interbedded in complex ways due to meandering of the river throughout its history.



SOURCE: Emmons, 1979

FIGURE 2-15 THICKNESS OF THE UNCONSOLIDATED VALLEY FILL IN THE DCP AREA



SOURCE: Bergstrom, 1956

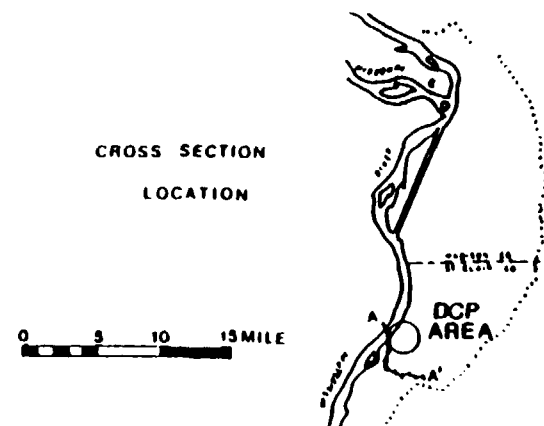
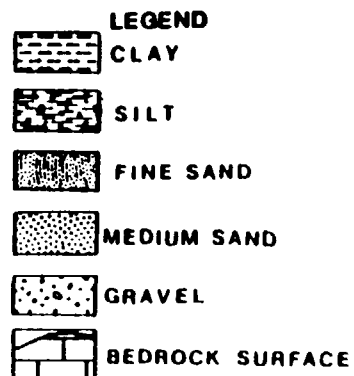


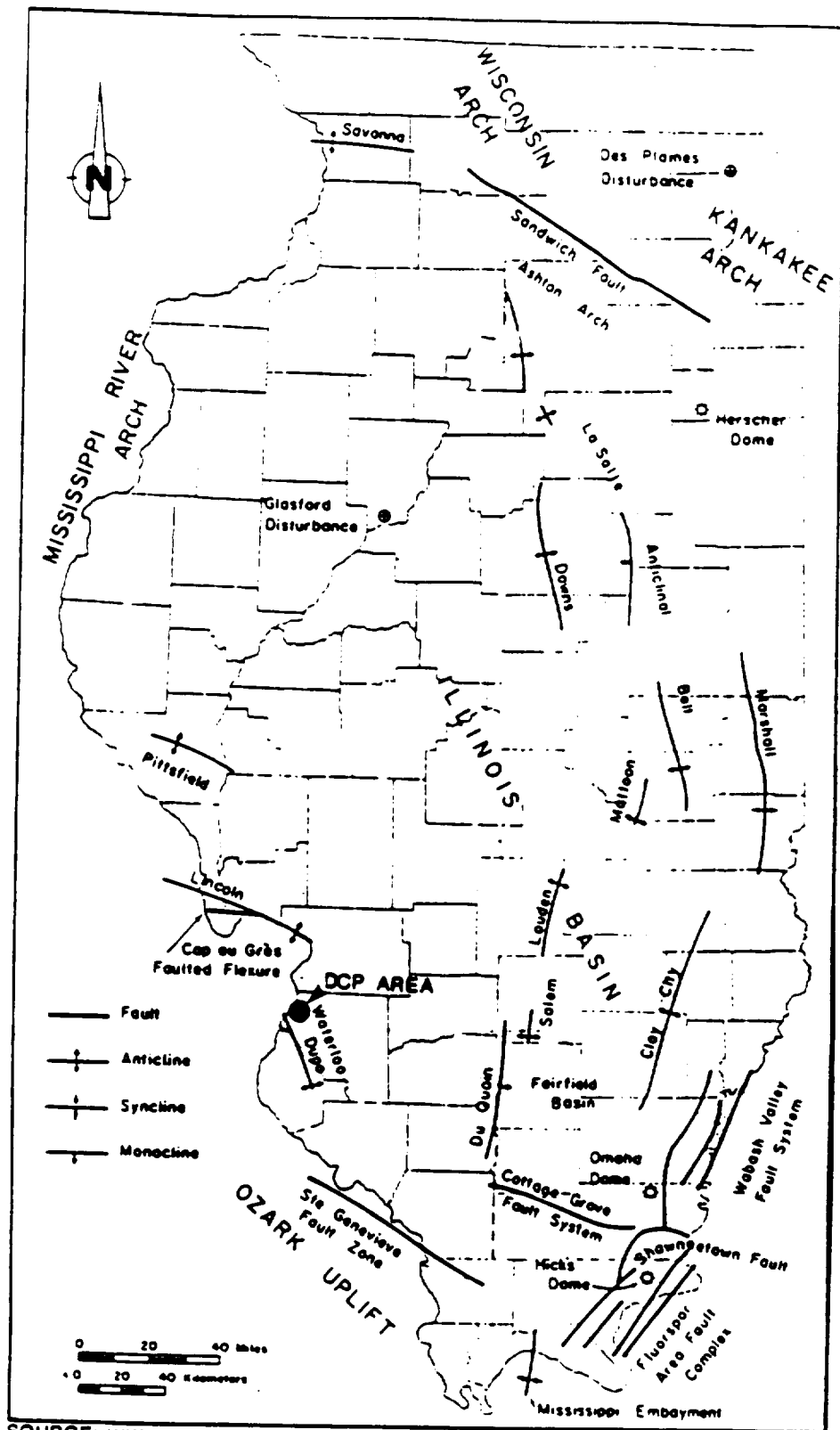
FIGURE 2-16 CROSS-SECTION OF THE VALLEY FILL IN THE VICINITY OF DCP AREA

A third, minor formation noted locally within the floodplain, but not discovered within the site investigation area, is the Peyton Colluvium. This material is composed of fine-grained silt (loess) and clay (till) which has slumped from upland areas and accumulated at the base of steep bluffs.

Immediately adjacent to the floodplain (and 3.5 to 5 miles east-southeast of the sites) is an upland area marked by a steep bluff (50 to 150 feet above surrounding terrain). Structurally, these upland areas are based unconformably on bedrock (which has not been eroded as deeply as the adjacent valley), and consist of 10 to 100 feet of unconsolidated sediments of predominantly glacial origin. No upland formations exist in the study area; however, erosion and slumping of the upland has provided the parent material for the Cahokia Formation and Peyton Colluvium, which are found in the floodplain.

The entire study area is underlain by relatively soft sedimentary rock layers. Typically these rocks consist of shale, limestone, and sandstone. The earliest sedimentary rock overlying the granite basement rock is Cambrian-age sandstone, limestone, dolomite, and shale. The Ordovician system overlies the Cambrian deposits. Its formations also consist of sandstone, dolomite, limestone, and shale. Overlying the Ordovician is the Silurian System, consisting of numerous limestone layers. Next youngest is the Devonian System, with limestone, sandstone, and shale formations. At the top of the sequence is the Mississippian System containing numerous limestone, shale, siltstone, dolomite, and sandstone layers. Significant bedrock formations of the Mississippian System include the St. Genevieve and St. Louis limestones, which represent the bedrock surface below the DCP study area. Although absent in the study area, the Pennsylvanian System is present in the adjacent highlands and at one bedrock high located within the valley south of the site area. This system contains various sandstones, siltstones, and shale formations.

Bedrock structure in the area appears to be controlled by a significant fold, known as the Waterloo anticline, and by fluvial erosion (primarily by the Mississippi River). The fold is centered approximately 6 miles south of the site area, and the structure trends north-northwest (see Figure 2-17). This fold has bent the overlying



SOURCE: Willmann et al., 1975.

FIGURE 2-17 PRINCIPAL GEOLOGIC STRUCTURES OF ILLINOIS

rock in the area, producing a gentle east-northeast of up to 3% on the bedrock strata. This dip allows the deep strata to be exposed by bedrock valley erosional processes southwest of the study area, while maintaining these same formations at a deeper elevation to the northeast of the study area.

2.4 GROUNDWATER GEOLOGY

Groundwater in the DCP study area exists in both the unconsolidated valley fill and the underlying Mississippian limestone and sandstone formations. Where these bedrock formations are located immediately below the unconsolidated material, sufficient groundwater is available for small or medium users. However, because of the abundance of groundwater in the valley fill sand and gravel, the bedrock aquifer is of little significance in the study area. The majority of available groundwater in the study area is present in, and obtained from, the valley fill materials. The Illinois State Water Survey (ISWS) has identified the study area as one in which the chances of obtaining well yields of 500 gallons per minute (gpm) or more are good. The coarsest deposits, which are most favorable for water development, are commonly encountered near bedrock and generally average 30 to 40 feet in thickness. However, because of the alluvial nature of deposits in the study area, sand and gravel deposits which yield significant quantities of groundwater are commonly found in the study area nearer the ground surface.

Horizontal groundwater movement in the shallow deposits throughout the study area generally follows the land surface topography, with lateral movement toward local discharge zones (wells and small streams), and some movement into the deeper unconsolidated aquifers. Groundwater in the deeper unconsolidated valley fill deposits generally follows the bedrock surface. Accordingly, groundwater generally flows downstream through the sand and gravel aquifers in much the same direction as the original streamflow, but at a much slower rate.

Recharge of groundwater in the study area is received from direct infiltration of precipitation and runoff, subsurface flow of infiltrated precipitation from the bluff area to the east, and induced infiltration from adjacent riverbeds where pumpage has lowered the water table below

the level of the river. Direct recharge of the water table captures a portion of the annual precipitation. A major portion of the precipitation runs off to streams or is lost by evapotranspiration before it reaches the aquifer. Nevertheless, precipitation is probably the most important recharge source for the study area as a whole. The amount of surface recharge that reaches the saturation zone depends upon many factors, including the character of the soil and other materials above the water table, the topography, vegetative cover, land use, soil moisture, depth to the water table, the intensity and seasonal distribution of precipitation, and temperature. Because of the low relief and limited runoff in the study area, and because the upper silt and clay fill is not so impermeable as to prevent appreciable recharge, most of the precipitation either evaporates or seeps into the soil. Because of the extensive flood-control network in the area, recharge from floodwaters provides only limited groundwater recharge to the area. Based upon a modified form of the Darcy equation, Schicht (1965) calculated the average rate of surface recharge to be about 371,000 gallons per day/square mile (gpd/mi²) for the study area.

Presently, groundwater levels in the DCP study area range from approximately 15 feet to 28 feet below ground surface. The depth to groundwater increases in an east to west direction toward the Mississippi River. Groundwater levels have historically varied as much as 50 feet due to withdrawals from industrial and municipal pumping centers. The significance of past groundwater pumpage is discussed in Section 4.1.3 of this report.

2.5 WATER RESOURCES

An assessment of groundwater and surface water resources in the DCP area was performed to evaluate the potential impact of project site activities on these resources. Information and data for this assessment were collected from the following sources:

- Illinois State Geological Survey (ISGS), Champaign, Illinois
- Illinois State Water Survey (ISWS), Champaign, Illinois
- Illinois Environmental Protection Agency (IEPA), Division Public Water Supplies, Collinsville, Illinois

- Illinois American Water Company, East St. Louis, Illinois
- U.S. Army Corps of Engineers (COE), St. Louis, Missouri
- Illinois Department of Public Health (IDPH), Edwardsville, Illinois
- Village of Cahokia Water Department
- Commonfields of Cahokia Public Water District, Cahokia, Illinois
- Village of Dupon Water Department
- Prairie DuPont Public Water District
- Hurst-Rosche Engineers, Inc., East St. Louis, Illinois
- University of Illinois Agricultural Extension Service, Belleville, Illinois
- Geraghty & Miller Groundwater Consultants (G & M)
(Hydrogeologic reports prepared for Monsanto and Sauget Sanitary Development and Research Association)

Public, private, and industrial water supplies and usage were investigated for this assessment.

Hazard Ranking System (HRS) scoring typically has addressed water usage within a 3-mile radius of the site to be scored. Due to the extent and severity of contamination found in the DCP study area, the range of this assessment was expanded to include potential target areas outside of this radius.

The primary source of drinking water for area residents is an intake in the Mississippi River. This intake is located at river mile 181, approximately 3 miles north of the DCP study area. The drinking water intake is owned and operated by the Illinois American Water Company (IAWC) of East St. Louis, and it services the majority of residences in the vicinity of the DCP area. IAWC supplies water to residents in East St. Louis, Centerville, Alorton, Sauget, and several towns located north of East St. Louis. The water intake location and distribution system for IAWC are presented in Figure 2-18.

In addition to the IAWC distribution network, several companies and municipalities purchase water from IAWC for distribution to towns in the general DCP area. The Commonfields of Cahokia Public Water District purchases water from IAWC and distributes it to portions of Cahokia and

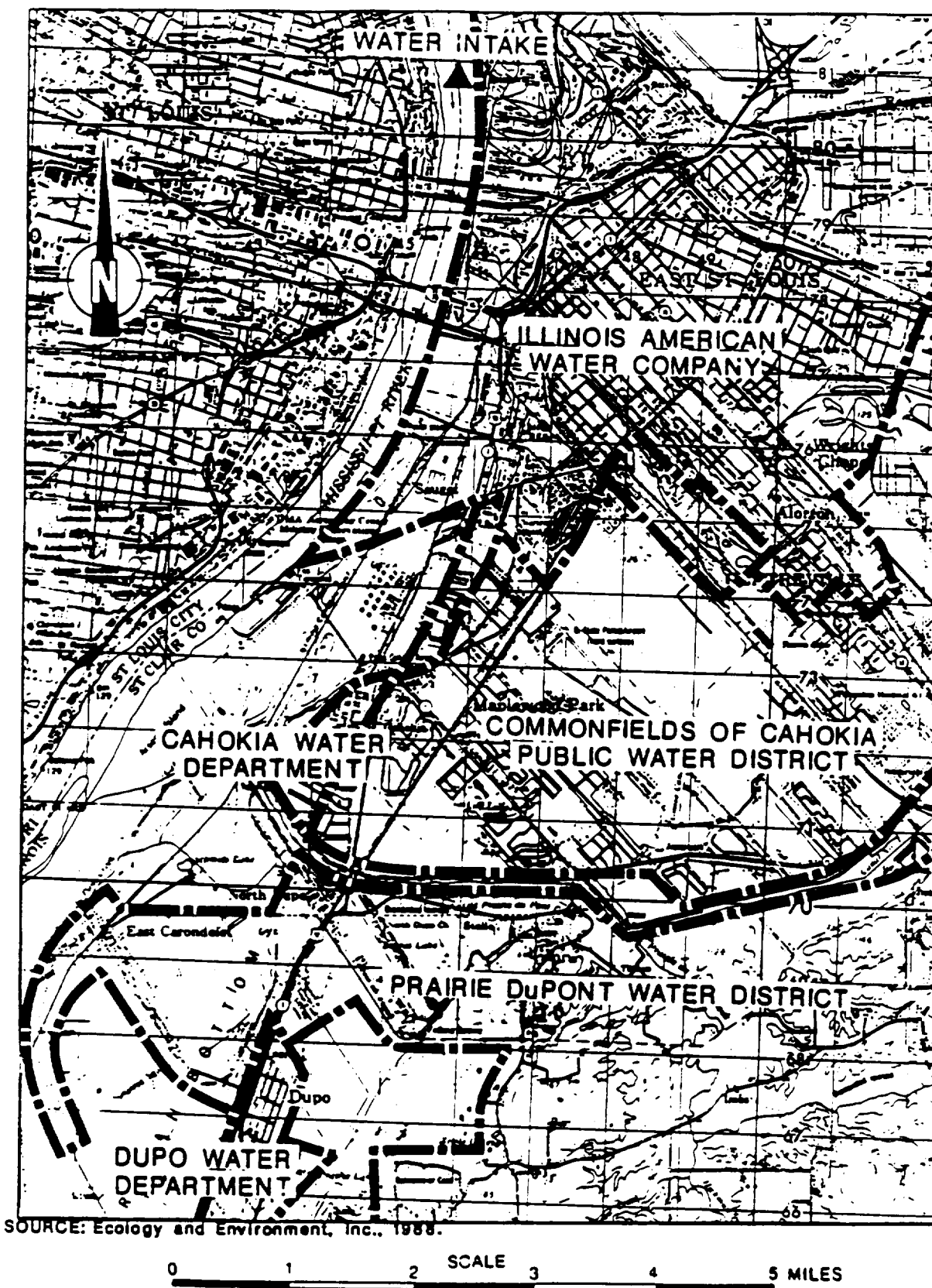


FIGURE 2-18 DISTRIBUTION OF PUBLIC WATER SUPPLY SYSTEMS IN THE DCP AREA

Centerville Township (see Figure 2-18). The Cahokia Water Department also purchases water from IAWC and distributes it to small residential areas in the west and southwest portions of Cahokia. The Village of Dupo, located approximately 3.5 miles south of the DCP area, is supplied by water purchased from IAWC and distributed through the Dupo Water Department. Dupo also provides water to the Prairie DuPont Public Water District, which includes the towns of North Dupo and East Carondelet.

Although the majority of residents in the DCP area are supplied drinking water by public systems, many others rely on private groundwater sources. (See Section 2.4 for a discussion of local groundwater availability.) Several of the residents relying on private sources for drinking water live south of the general DCP area. Additionally, due to the relatively shallow water table and the abundance of groundwater resources, many additional residents use shallow wells to water lawns and gardens.

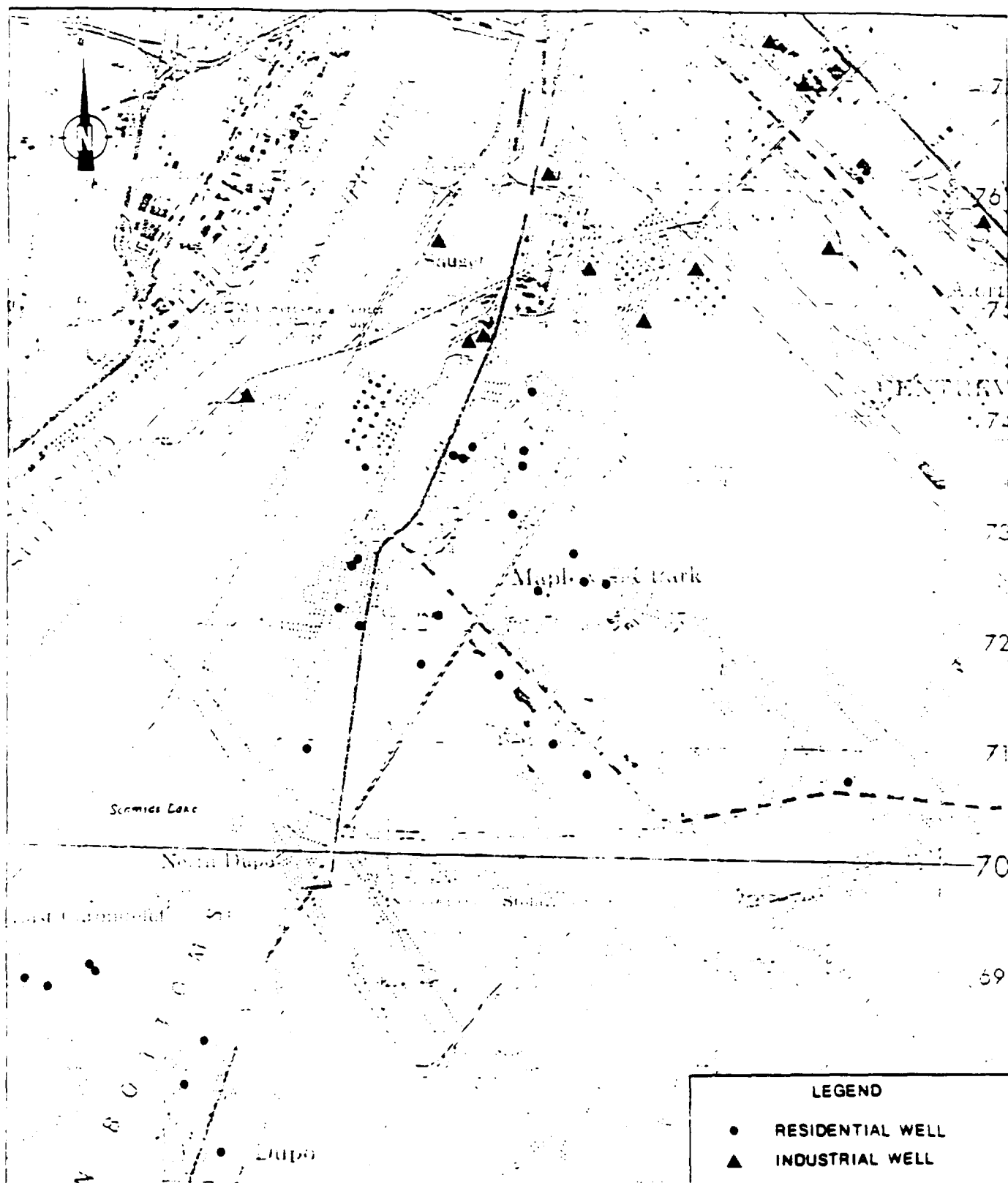
A review of IDPH and ISGS files indicated that at least 50 area residences have wells which are used for drinking water or irrigation purposes. These wells are located in Cahokia (23 wells), East St. Louis (5), East Carondelet (16), and Dupo (6). Located private wells are shown in Figure 2-19. The nearest private wells to any of the DCP sites are located on Judith Lane, immediately south of the Area 1 sites. Based on interviews with these well owners, only one of the five wells located in this area is used occasionally as a source of drinking water and the other four are never used for this purpose.

It must be noted that the estimate of 50 wells given above is a low approximation of the number of private wells in the DCP area. The figure is based on information in IDPH files, and indicates only the wells sampled or analyzed by IDPH within the last 2 years. The figure does not include the homes on Judith Lane known to have private well supplies, nor does it include an unknown number of residences in the Schmidts Lake area (approximately 3 miles southwest of the Area 1 sites). This area is not covered by any public water distribution, and residents in the Schmidts Lake area rely entirely on groundwater wells for their drinking water supply. A Southwestern Illinois Metropolitan and Regional Planning Commission (SIMRPC) report (1983) listed 69 residences in Centerville Township (including the towns of Sauget, Cahokia,

Alorton, and Centreville) which use private water systems. The same report lists 57 residences in East St. Louis and 365 residences in Sugarloaf Township (including the towns of Dupo, North Dupo, and East Carondolet) which use private well supplies. In summary, although the majority of residences in the general project area are serviced by public water supply systems, well over 50 homes utilize private well supplies for drinking water or irrigation purposes.

Industrial groundwater usage in the DCP area has been very extensive in the past. Peak use occurred in 1962 when groundwater pumpage exceeded 35 million gallons per day (mgd). The historical aspect of industrial groundwater pumpage is discussed in Section 4.1.3 of this report. Relatively few industries presently utilize well-supplied groundwater for process or cooling water. Although a general degradation in groundwater quality in the area is one likely reason for the cessation of groundwater pumping by area industries, specific documentation relating well abandonment to contamination has not been located. ISWS file information listed 13 industries as potential groundwater users in Townships 1 and 2 North and Ranges 9 and 10 West, which covers the entire project area from National City on the north, to the Village of Dupo on the south. Telephone contacts with these listed industries revealed that seven facilities have active wells, with uses ranging from filling backup firefighting reservoirs to use as process or cooling water. In addition to the wells listed in ISWS files, ISGS well log files indicate that up to 20 additional industrial wells are located within a 3-mile radius of the Area 1 sites. No attempts were made to contact industries listed for these wells on ISGS well logs. All of the industrial wells are screened in the Henry Formation sand and gravel aquifer at depths ranging from 35 to 110 feet. Facilities with active water wells used for industrial purposes are shown on Figure 2-19. Total groundwater pumpage from industrial sources in the project area is presently estimated to be less than 0.5 mgd.

Surface water use in the immediate DCP area (river mile 178) is limited to recreation and freight trafficking. The surface water intake (river mile 181) which supplies drinking water to residents on the Illinois side of the Mississippi River was discussed previously in this section. The City of St. Louis is also supplied drinking water from an



SOURCE: Ecology and Environment, Inc., 1988.

0 1 2 3 4 MILES

FIGURE 2-19 RESIDENTIAL AND INDUSTRIAL WELL LOCATIONS IN THE DCP AREA

intake in the river. This intake is located at river mile 190, approximately 12 miles north of the DCP area. Residents in St. Louis County, Missouri, including all of the surrounding suburban areas, are serviced by the St. Louis County Public Water District, which utilizes intakes in the Missouri and Meramec rivers as water sources. According to the available sources, the nearest downstream surface intake on the Illinois side of the Mississippi River is located at river mile 110, approximately 65 miles south of the project area. This intake supplies drinking water to residents in the Town of Chester and surrounding areas in Randolph County, Illinois. The nearest potentially impacted public water supply on the Missouri side of the river is located at river mile 149, approximately 28 miles south of the DCP area. The Village of Crystal City, Missouri (pop. 4,000), located 28 miles south of the DCP area, utilizes a Ranney well adjacent to the Mississippi River as a source for drinking water. Although this is not actually a surface water intake, it is assumed that the well draws river water due to its construction and location adjacent to the river.

An assessment of irrigational use of groundwater and surface water in the DCP area was also conducted as part of the water supply search. Although agricultural land is found throughout the immediate project area, this land is apparently not irrigated. The nearest irrigated land, other than residential lawns and gardens, is located in the Schmids Lake-East Carondolet area. According to the University of Illinois Agricultural Extension Service, three wells in this area are used to irrigate approximately 400 acres of farmland. Approximately 1.9 mgd are withdrawn from water wells for irrigational use in St. Clair County (Kirk et al. 1982). Other than the three wells located in Schmids Lake-East Carondolet area, no specific information concerning the location of wells used for irrigation is available.

2.6 SITE HISTORY

The DCP area has an extensive and complex history of waste disposal activities. A brief history of individual project sites was previously outlined in a report titled "Description of Current Situation at the Dead Creek Project Sites," completed by E & E in July 1986 (provided as Appendix A). Because site histories were described in the July 1986

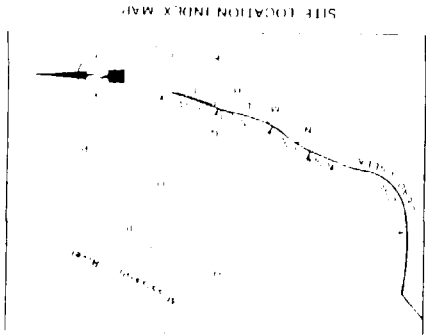
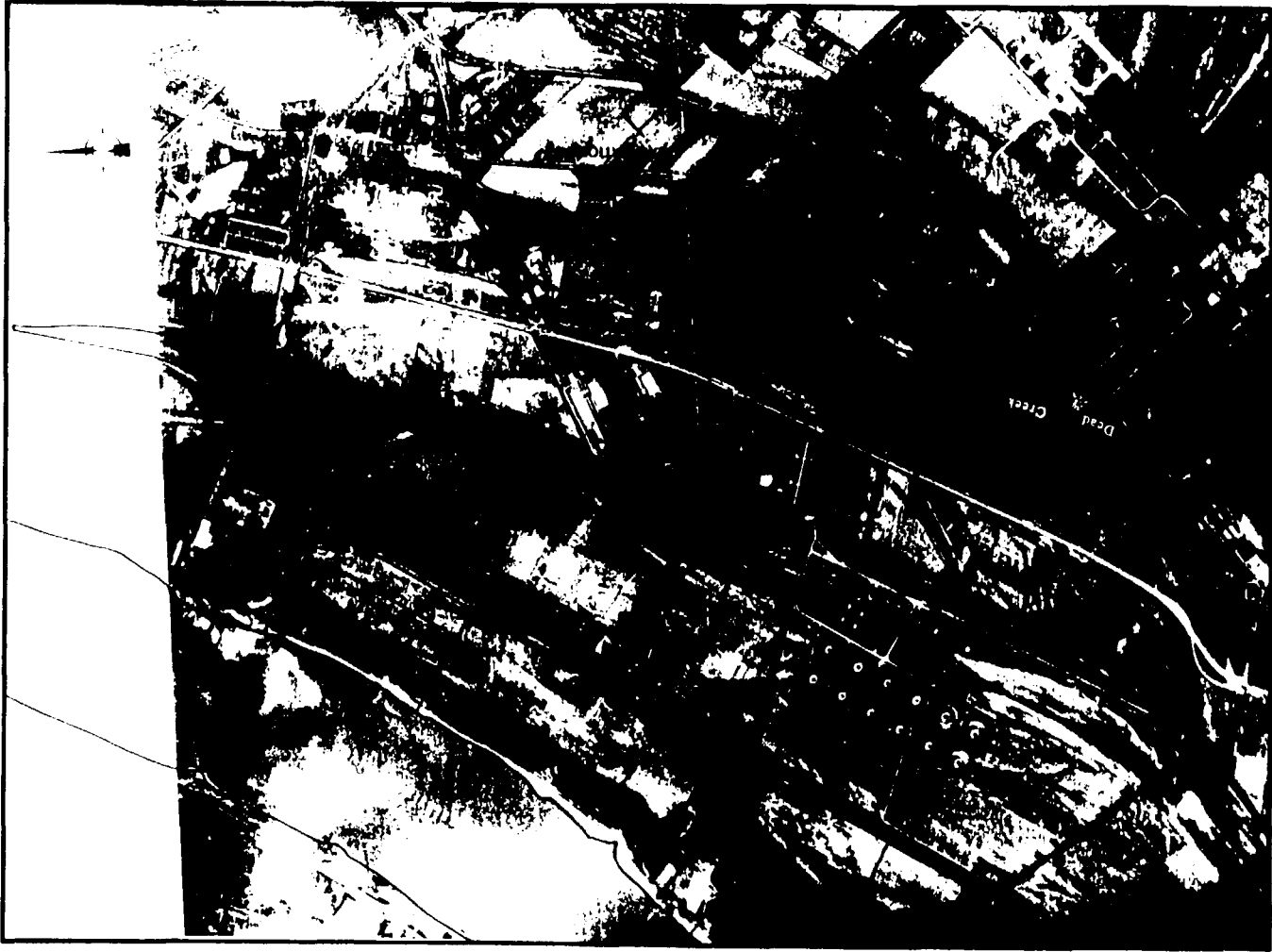
report, this section will be limited to a discussion of points not covered in the that report. Items specifically presented in this section will include: an examination of historical aerial photographs, a brief chronology of local investigations conducted by governmental agencies and area firms, and a discussion of site ownership at the time of disposal activities.

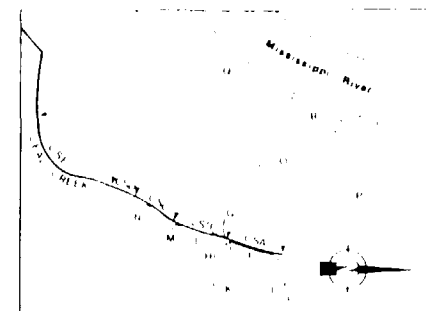
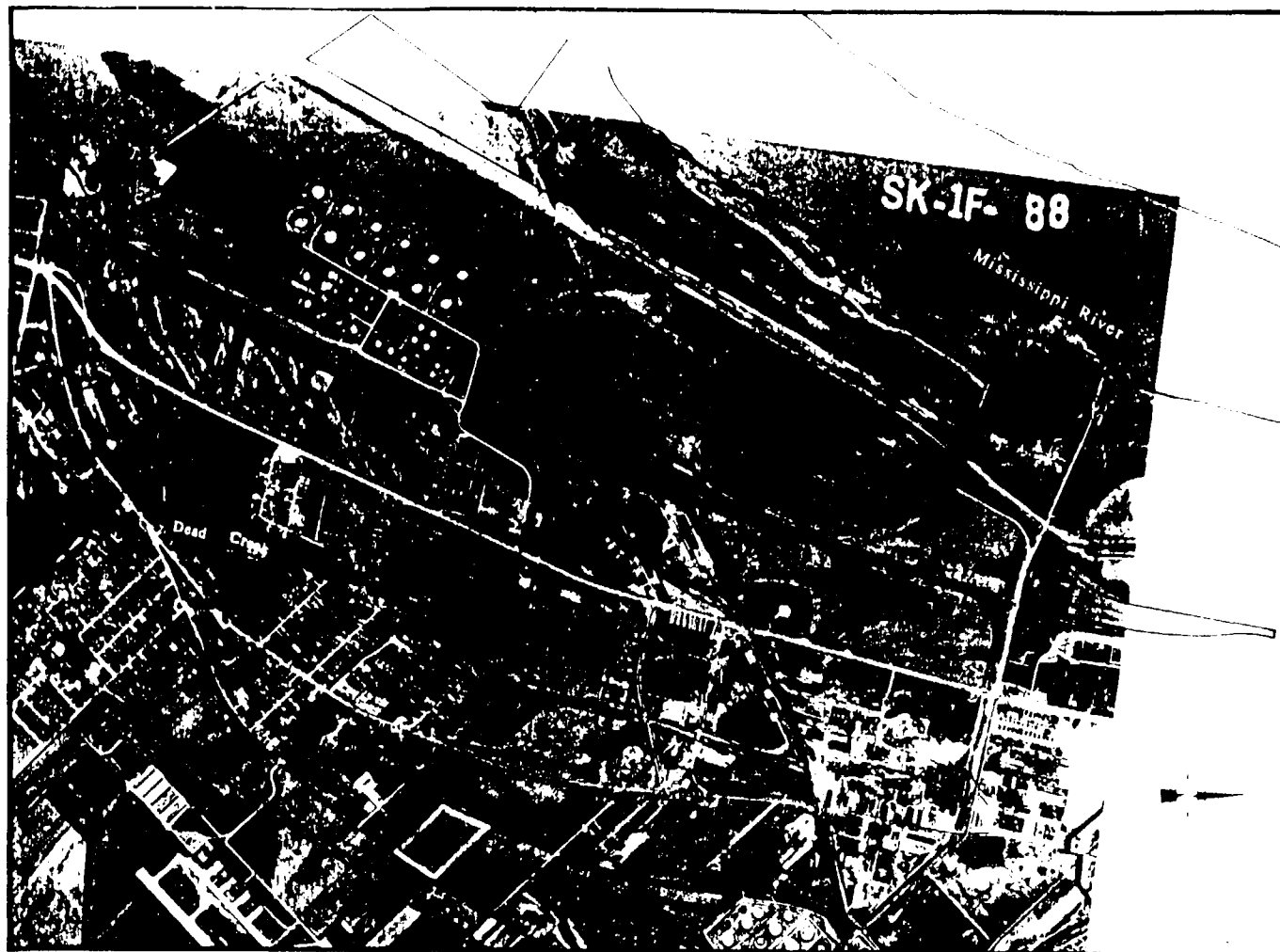
2.6.1 Analysis of Aerial Photographs

Historical aerial photographs were used initially by IEPA to identify potential sources of contamination observed in the DCP study area. These photographs also provided a chronology of disposal activities at the DCP sites. The photographs revealed several excavated areas which were thought to have been subsequently used for waste disposal activities. IEPA then conducted a preliminary hydrogeological investigation in the area and presented the findings, along with an assessment of the photographs (St. John 1981). In order to assess site conditions and to more accurately locate site boundaries, E & E obtained aerial photographs for the years 1937, 1950, 1955, 1962, 1973, 1978, and 1985. Results of this analysis were also used to determine placement of soil gas monitoring points, soil borings, and monitoring wells.

The aerial photograph from 1937 (see Figure 2-20) shows the project area with present site boundaries and distinguishing features superimposed on it. The Sauget area had been significantly industrialized at the time, indicating that some form of industrial waste disposal activity probably occurred in the area prior to 1937. The only current DCP sites evident in the photograph are Sites H and I, which were apparently undergoing initial excavation at the time. Queeny Avenue had not yet been constructed, and a single excavation extended north of Site H, across the present location of Queeny Avenue, and onto the southern portion of Site I (the present boundaries for Sites H and E were based on property ownerships and the separation of the areas by Queeny Avenue). Figure 2-20 also shows Dead Creek as an uninterrupted stream, with little activity along the banks of the creek.

The aerial photograph from 1950 (see Figure 2-21) shows significant change in the DCP area. Several additional excavations can be seen in the general area around Dead Creek, and industrial activity in the area





SITE LOCATION INDEX MAP

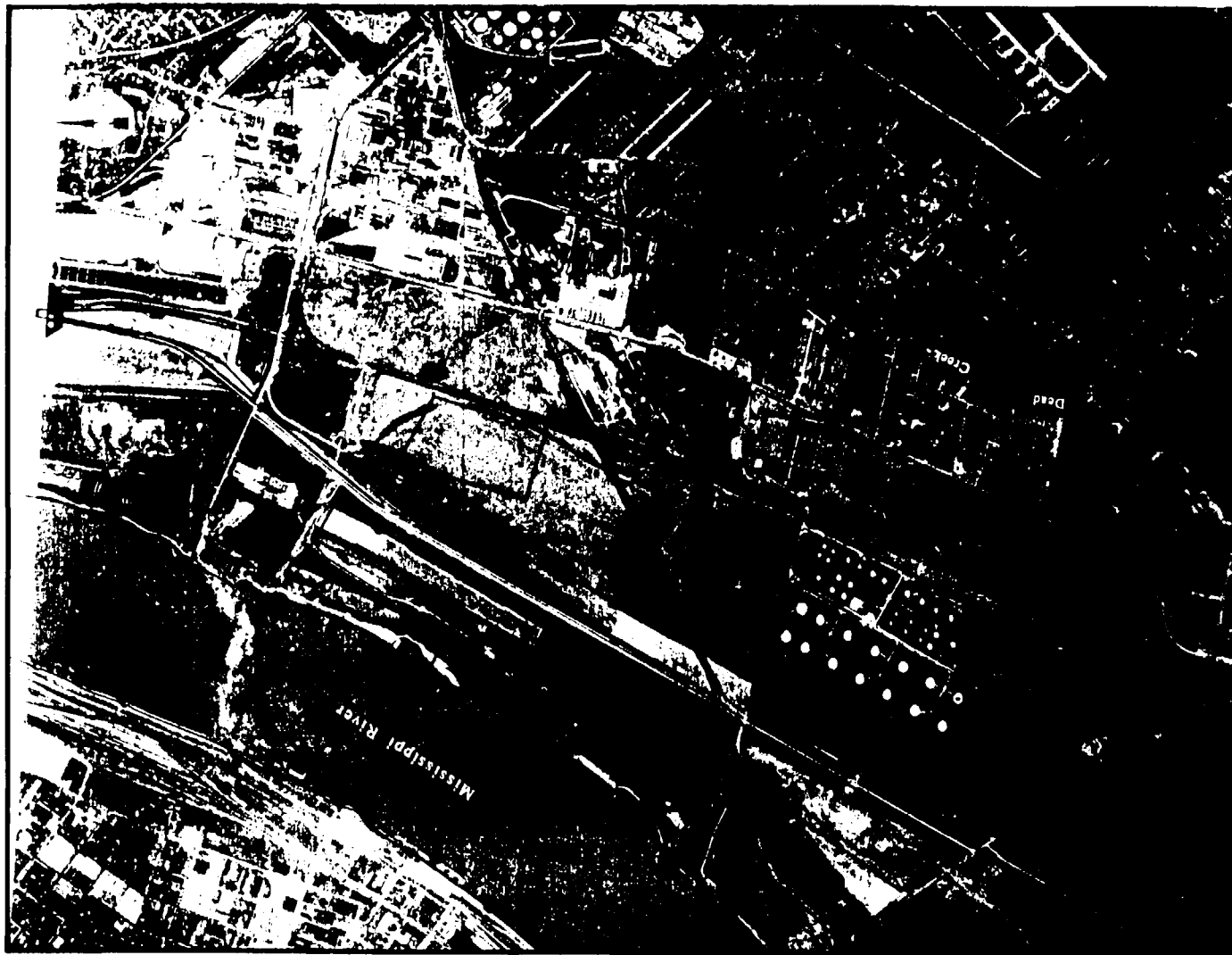
FIGURE 2-21 AERIAL PHOTOGRAPHY
OF DCP AREA, 1950

increased significantly. New excavations visible in the figure were located at the areas now designated as Sites G, I, K, M, and N. All of these pits were excavated into the water table, which was approximately 25 feet below ground surface at that time (Bruin 1953). The majority of Site H had been filled by 1950, with the exception of a small area in the northwest corner of the site. Queeny Avenue was completed by 1950. This construction divided the pit initially seen in the 1937 photograph. Marked discoloration can be seen in CS-A and the northern portion of CS-B, indicating disposal into the creek or runoff from the pits entering the creek. Residential development had also increased in the DCP area, particularly south of Site M along Dead Creek.

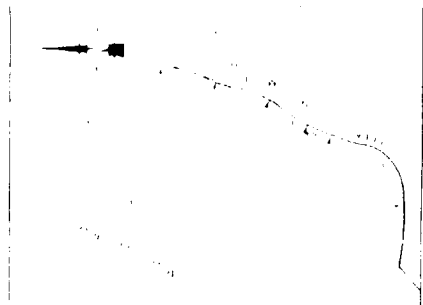
The aerial photograph from 1955 (see Figure 2-22) shows a new excavation in the eastern portion of Site J. The initial pit at Sites H and I had been completely filled, and the area appears to be low-lying in relationship to the surrounding topography, indicating that material in the pit had settled. Disposal activities continued in the northern part of Sites I and G. The excavations at Sites K, M, and N remained essentially unchanged, although the water table was no longer evident in any of the three sites. This is probably due to the large increase in groundwater pumpage between 1950 and 1955, which lowered the water table in the area between 5 and 10 feet. Residential development continued to increase, most notably on Walnut Street which is immediately east of Site M. Initial activity was also seen at Sites Q and R, adjacent to the Mississippi River.

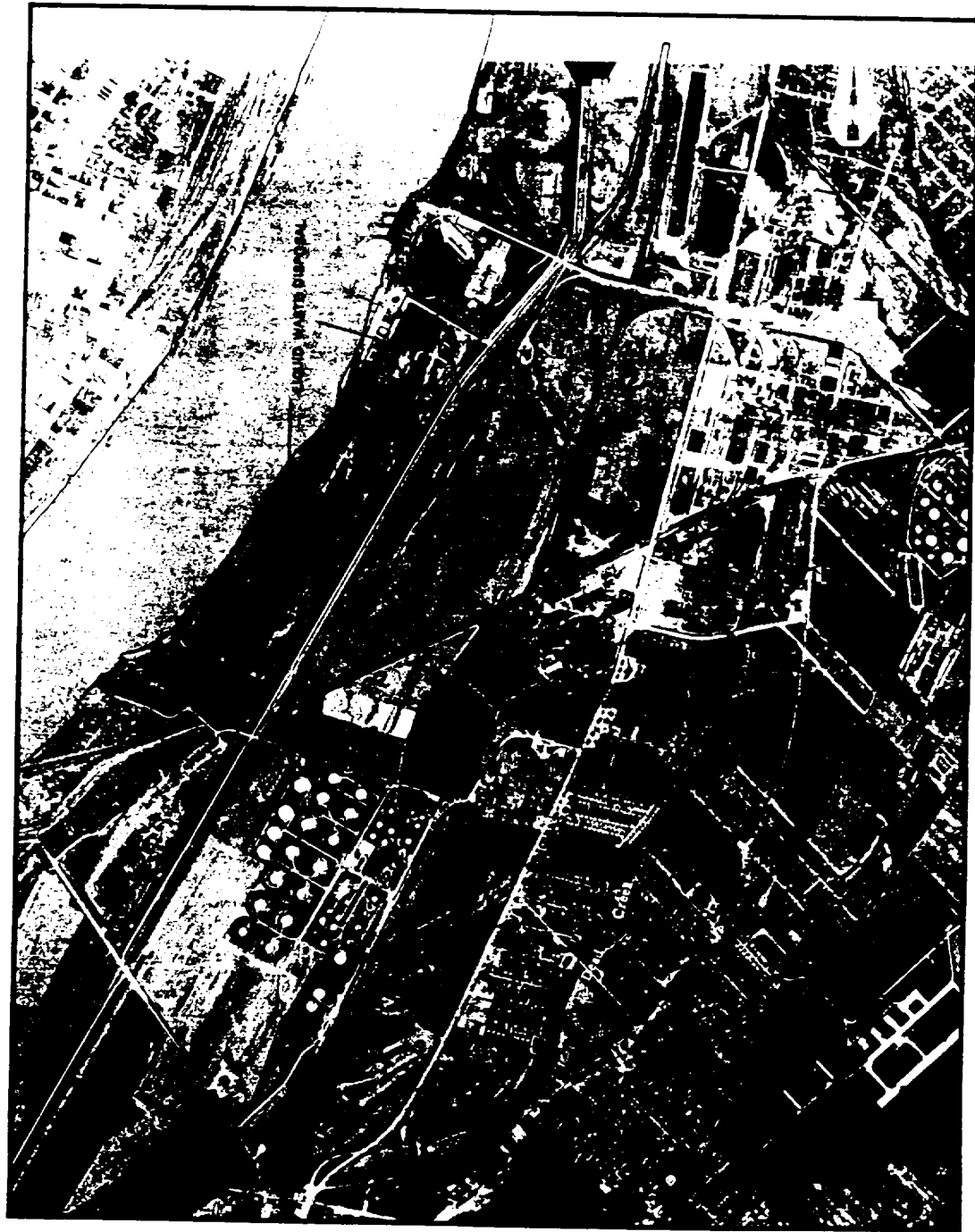
The aerial photograph from 1962 (see Figure 2-23) shows a marked increase in what appears to be disposal activity at Sites Q and R. A tank farm had been constructed along the river adjacent to Site R. Several small excavated areas are seen in the northern portion of both sites, and waste material is evident along the east side of Site Q. Disposal activity continued at Site G, and the photograph shows the site expanded to the west toward Illinois Route 3. The north excavation at Site I and the pits at Site K and Site N had been filled. Site M did not change, although water is again evident in the pit. The initial excavation at Site J had increased in size, and a second pit is now seen to the north of the plant buildings at the site. Surface disposal is not evident at Site J in the 1962 photograph. The only remaining

FIGURE 2. 22. AIR PHOTOGRAPH OF THE SITE LOCATION.



SITE LOCATION MAP





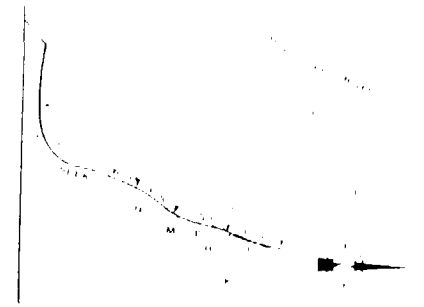
SITE LOCATION MAP - 400'

FIGURE 2. Aerial photograph of the site.

project sites not active by 1962 were Sites L, O, and P. Discoloration is again seen in CS-A and CS-B, and dark stains are also evident along the west bank of CS-B in an area adjacent to Site G. These stains are distinguishable from the lighter discoloration mentioned previously, and are possibly the result of discharge from an effluent pipe reported to have been utilized by the Midwest Rubber Company.

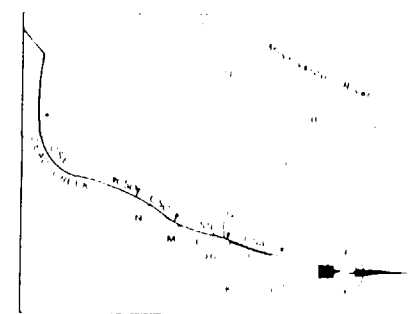
The aerial photograph from 1973 (see Figure 2-24) shows the first evidence of disposal activity at the three remaining project sites: Site L, Site O, and Site P. The former surface impoundment at Site L is clearly identifiable immediately to the north of a cultivated field. The water in CS-B is again discolored, particularly in the area adjacent to Site L. The sludge lagoons at Site O appear to have been active for several years, and a dark liquid or sludge-like material is visible in the two west lagoons. A large amount of excavation is seen at Site P, with dark staining evident in the south-central and eastern portions of the site. The present boundaries of Site R are defined, and significant liquid waste disposal is evident in the southern one-half of the site. Several individual cells, or bermed areas, are seen in this area. Disposal activities appear to have been completed in the northern portion of Site Q (adjacent to Site R), although landfiling continues to the south. With the exception of Site L, activity at the sites in the immediate Dead Creek area appears to have been completed. A building has been constructed along the west side of Site G in an area where previous photographs indicated waste disposal activity. Site I has been graded and is being used as a storage area. The large pit at Site J has been partially filled, but ponded water is still visible. Initial activity is also apparent in the surface disposal area to the northeast of the plant buildings at Site J. Although the excavation at Site K had apparently been filled previously (see Figure 2-23), activity is again seen in this area. A large pit had again been excavated, and a dark liquid (possibly water) is seen throughout the excavated area. Commercial and residential development in the area had approached present conditions.

The aerial photograph from 1978 (see Figure 2-25) again shows significant activity at Sites O and P. Disposal activities at Site Q and R appear to have been completed. Sites J and L remain unchanged.



SITE LOCATION INDEX MAP

FIGURE 2-24 AERIAL PHOTOGRAPH
OF D.F. AREA - 1974



SITE LOCATION INDEX MAP

FIGURE 2-25 AERIAL PHOTOGRAPH
OF DECEMBER 1976

The excavation at Site K has again been filled. Light-colored staining remained evident in CS-A and CS-B. This observation is consistent with complaints from local residents to IEPA concerning odors and discoloration in the creek during this time. The appearance of the remaining project sites shown on this figure resembles current conditions in the DCP area.

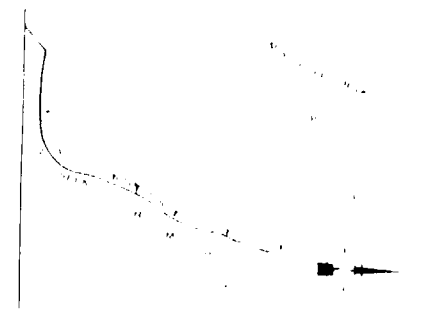
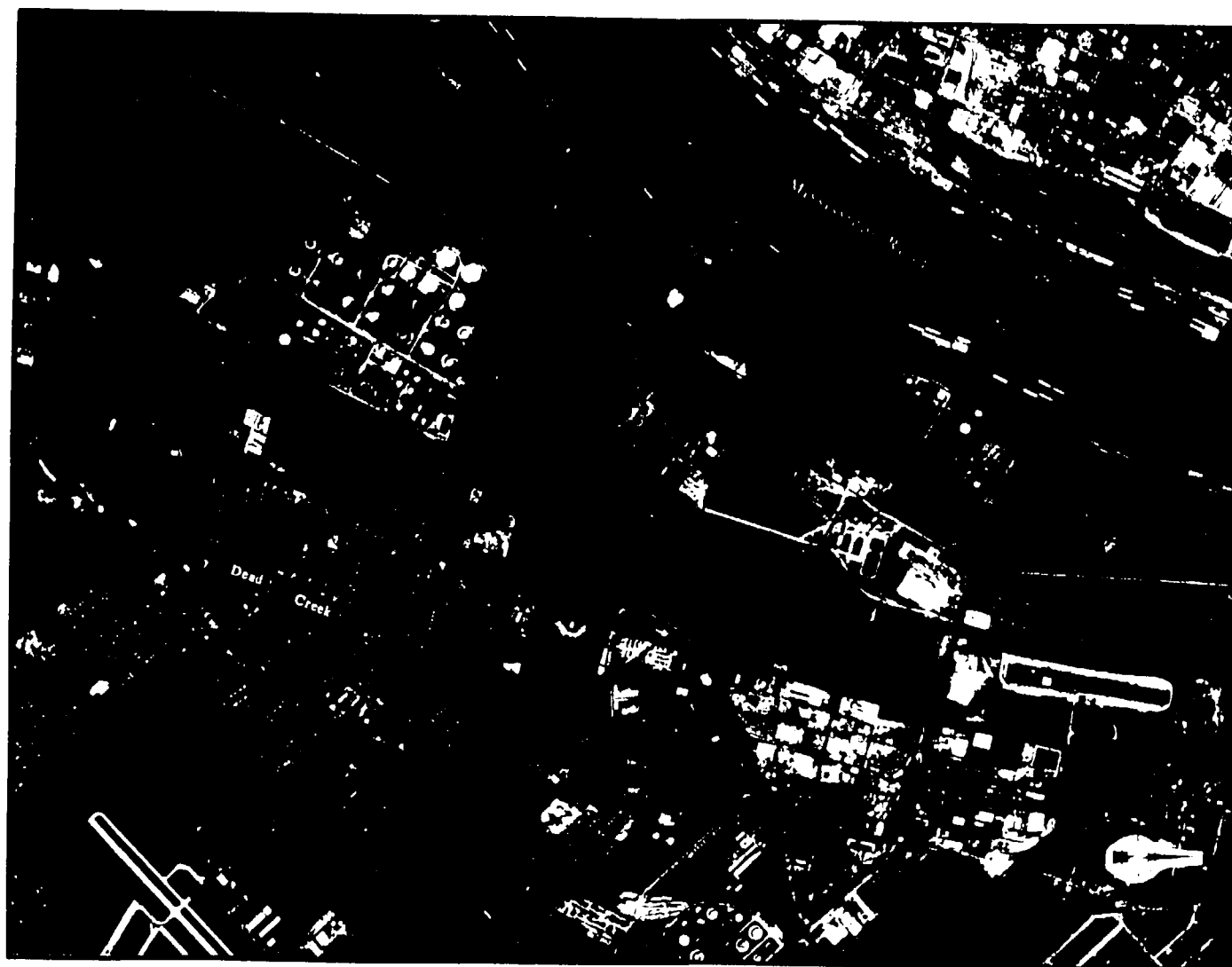
The aerial photograph from 1985 (see Figure 2-26) shows site conditions at the onset of this project. Waste disposal activities had been completed at all DCP sites. Sites showing waste material at the surface include Site G, Site J, and Site P. Site O and Site R had been capped and vegetated, and construction of the new regional wastewater treatment plant (south of Site O) underway. Large piles of coal and cinders are evident on the surface of Site Q. A building and parking area have been completed in the southeast corner of Site P. Water is still evident in the pits at Site J and Site M, and the impoundment at Site L had been filled.

It should be noted that the analysis of historical aerial photographs was limited to only those sites included in this study. Several other potential sources of contamination, such as the Route 3 Drum Site, are also evident in the photographs.

2.6.2 Chronology of Site Activities

The DCP area has a long history of investigation activity by government agencies and private consultants to area industries. A brief chronology of these activities, with references to specific project sites, is as follows:

March 1942	Correspondence from an Illinois Sanitary Water Board engineer represents the earliest available file information concerning waste discharge and contamination in Dead Creek and the Mississippi River.
March 1967	Sauget & Co. filed a registration application for disposal site (Site Q) to the Illinois Department of Public Health (IDPH).



SITE LOCATION MAP

FIGURE 26. AERIAL PHOTOGRAPH
OF DEAD CREEK AREA

August 1968	IDPH sampled monitoring wells at Site R. Phenols detected in all wells sampled.
August 1968	In response to an IDPH request, Monsanto submitted a waste inventory of material disposed of at Site R. Inventory included 35,470 cubic yards of material, listed by chemical category.
March 1971	The Cahokia Health Department received complaints from area residents concerning chemical discharges to Dead Creek.
April 1971	IDPH inspection of Dead Creek (CS-B) indicated no apparent discharge from CS-A following the blockage of the Queeny Avenue culvert.
April 1971	IEPA inspection of Site R revealed disposal of bulk chemical waste and drums.
April 1971	IEPA inspector observed Waggoner Company (Site L) tank truck discharging material directly to Dead Creek.
May 1971	Illinois Pollution Control Board (PCB) order 71-29 issued to Sauget & Co. to respond to request for information concerning Site R, and to cease using cinders for final cover at Site Q.
June 1971	Monsanto responded to PCB order 71-29, listing 18,400 cubic yards of chemical wastes disposed of at Site R for the year 1971.
July 1971	IEPA cited Waggoner Company for discharges to Dead Creek.

August 1971	Waggoner responded to IEPA, stating discharges to Dead Creek had ceased, and that the company was using a pit for discharges (Site L) at that time.
September 1971- August 1972	IEPA conducted monthly inspections at Site Q, citing inadequacy of daily and final cover, and disposal of liquid wastes.
August 1972	IEPA conducted leach tests of cinders used as cover at Site Q. Material determined to be inadequate due to high metal content and permeability.
December 1972	IEPA sampled monitoring wells at Site R. Phenols detected in all wells sampled.
January 1973	IEPA issued a permit to Sauget & Co. to operate landfill (Site P). The landfill was authorized to accept only non-chemical waste from Monsanto.
January 1973	IEPA sampled waste ponds at Site R. Limited analysis showed high concentrations of phenols.
February 1973	IEPA sampled monitoring wells at Site R. High chemical oxygen demand (COD) and phenols were detected in all samples.
March 1973	Mississippi River floodwaters inundated Sites Q and R. IEPA observed waste material in the water. Conditions persisted until May.
November 1973	Illinois Secretary of State revoked the authority of Sauget & Co. to transact business in the State of Illinois.

May 1974	IEPA sampling of monitoring wells at Site R indicated phenols in all samples.
January 1975	IEPA inspection of Site Q indicated that disposal activities had been completed at the site.
May 1975	IEPA received a complaint concerning chemical contamination in Dead Creek. Inspection revealed discoloration of water and creek bank along CS-A and CS-B.
October 1975	IEPA inspection at Site P indicated disposal of chemical waste from Monsanto in violation of the site permit.
February 1976	IEPA sampled monitoring wells and high volume Ranney well at Site R. PCBs detected in Ranney well.
September 1976	IEPA inspection at Site Q revealed underground fire and smoldering at the site. Condition persisted for approximately 1 month.
August 1977	Monsanto submitted correspondence to IEPA indicating that the company had ceased production of PCBs at its Krummrich plant.
October 1977	D'Appolonia Consulting Engineers retained by Monsanto to conduct a subsurface investigation of Site R and propose appropriate closure alternatives.
December 1977	IEPA inspection at Site P indicated disposal of 25 metal containers of phosphorus pentasulfide. Monsanto ordered to remove the material.

May 1978	Monsanto submitted closure plan for Site R to IEPA.
August 1978	PCB order 77-84 filed against Sauget & Co. to apply final cover at Site Q.
September 1978	Monsanto began closure operations at Site R which included covering, grading, capping, and securing the site.
July 1979	Complaints received by IEPA concerning fires and smoldering in Dead Creek (CS-B).
October 1979	Monsanto cited by IEPA for disposal of chemical packagings at Site P in violation of permit issued January 1973.
October 1979	IEPA sampled monitoring wells at Site R. Analysis revealed contaminants including chlorophenols, chlorobenzenes, and aniline derivatives in the samples.
October 1979	IEPA inspection at Site R indicated that closure operations at the site had been completed.
May 1980	IEPA received notice that chemical wastes and drums were uncovered during excavation work for a railroad spur at Site Q. File information indicates that construction workers at the site became nauseous; however, specific information concerning exposure-related illness has not been located.
May 1980	IEPA received additional complaints concerning fires in Dead Creek.

June 1980	IEPA and the University of Illinois conducted a joint investigation of effluents from industrial plants and water treatment plants. The report of this investigation indicated the presence of several mutagenic contaminants in the Sauget Waste Water Treatment Plant effluent.
August 1980	Incident in which local resident's dog died, apparently resulting from exposure to contaminants in the creek bed, reported to IEPA.
August 1980	The U.S. Food and Drug Administration (FDA) collected fish samples from the Mississippi River near Site R and the Sauget Waste Water Treatment Plant discharge point. Analysis of the samples indicated the presence of several PCB congeners and pesticides in downstream fish.
September 1980	IEPA surface water/sediment sampling revealed high concentrations of a wide variety of organic and inorganic contaminants in Dead Creek (CS-B through CS-E).
September 1980	IEPA placed a seal order on Dead Creek (CS-B and Site M), and the Illinois Department of Transportation (DOT) completed construction of a snow fence with warning signs around the area.
October 1980	IEPA conducted additional sediment sampling in the creek bed (CS-B) in conjunction with Monsanto. Results revealed widespread contamination in the area.
October 1980	IEPA initiated a hydrogeologic investigation in the Dead Creek area in order to determine the source(s) of contamination in the creek.

October 1980 IEPA collected air samples in the creek bed (CS-B). Results were not quantified, but revealed the presence of volatile organics and hydrocarbons.

get the info
October 1980 The Illinois Attorney General's office interviewed area residents who discussed past operation of several disposal pits in the area that reportedly received chemical wastes.

November 1980 IEPA sampled water and sediments in CS-A on Cerro Copper Products property. Results indicted high concentrations of PCBs and hydrocarbons.

December 1980 USEPA and TAT contractor inspected CS-B for possible 311 immediate removal action. Not deemed to be warranted.

March 1981 IEPA sampling of monitoring wells at Site R revealed high concentrations of a variety of organic contaminants.

March 1981 Following a long history of effluent problems, the Sauget Waste Water Treatment Plant submitted specifications for a pretreatment program to more efficiently treat its waste streams.

April 1981 IEPA completed report on hydrogeologic investigation in the Dead Creek area. Results indicated widespread groundwater and soil contamination. Report concluded that further investigation was necessary.

May 1981 Illinois Attorney General filed suit against Sauget & Co., alleging several violations of the Illinois Environmental Protection Act (Site Q).

May 1981	Monsanto filed CERCLA notification for the Sauget (Monsanto) Illinois Landfill on Falling Springs Road (Sites H and I). Also submitted notification for Site R.
June 1981	The Village of Sauget submitted CERCLA notification for former sludge lagoons (Site O). Notification indicated that lagoons had been neutralized and clay-capped.
August 1981	Patterson & Associates report outlined major discharges to the Mississippi River in the Sauget area, and indicated a discharge of 30 organic priority pollutants expected to exceed 0.5 million pounds.
September 1981	USEPA formed a Sauget task force to investigate past and present waste disposal activities in the area. The task force conducted limited investigations and interviews at Sauget area industries. Results from these investigations are described individually in this chronology (see USEPA investigations between 1981 and 1983).
October 1981	U.S. Food and Drug Administration collected fish samples from river upstream and downstream of Site R. Downstream fish contained several organic contaminants.
October 1981	IEPA sampled seeps adjacent to river at Site R and Site O. Results showed high concentrations of organics.
November 1981	USEPA TAT contractor sampled seeps at Site R. Higher chlorinated dioxins (hexa- through octa-) found in samples.

December 1981	IEPA issued supplemental permit to Sauget and Company to alter landfill operation at Site P due to the presence of a potable water line discovered in the center of the site. The water line remains in its original location. Considering the widespread groundwater contamination in the Sauget area, the water line may eventually be impacted by the presence of contaminants.
December 1981	Monsanto retained Law Engineering Company to drill additional test borings at Site R.
January 1982	USEPA FIT contractor conducted property search to determine the ownership of various waste disposal sites in the Sauget area.
March 1982	USEPA collected private well and garden soil samples at residences in the Dead Creek area. Results showed little contamination. Also sampled sediments in CS-A and well on Cerro Copper Products property. Organics detected in groundwater sample. Sediments showed concentrations of lead and cadmium above EP-toxicity limits.
March 1982	USEPA FIT contractor conducted air monitoring in CS-B. Organic vapor readings up to 900 ppm detected.
March 1982	USEPA sampled treatment plant effluent at the Mississippi River. Results indicated high levels of organic pollutants discharged to the river.

June 1982	Illinois Attorney General's office filed complaint against Monsanto, alleging several violations of the Illinois Environmental Protection Act.
July 1982	USEPA FIT contractor submitted HRS score for Site R. Site scored 7.23 and did not qualify for the NPL.
July 1982	Illinois Attorney General's office conducted a property search in support of proposed action at disposal sites.
October 1982	USEPA completed construction of chain-link fence around CS-B and Site M, replacing snow fence originally constructed by the IEPA.
December 1982	IEPA collected soil samples around Bliss Waste Oil tanks at Clayton Chemical in the vicinity of Site O. High levels of PCBs and pentachlorophenol detected. Dioxin contamination suspected.
January 1983	Construction began on the new American Bottoms regional wastewater treatment plant.
January 1983	Illinois Attorney General's office filed suit against Bliss and Clayton Chemical. Alleged water pollution hazard.
February 1983	IEPA inspected reported underground tank at Bliss and Clayton, near Site O. Analysis of samples from tank showed high levels of organics.

February 1983	IEPA and Envirodyne Engineers soil sampling revealed PCB and 2,3,7,8-TCDD (dioxin) contamination in an area northwest of Site O at the Sauget Waste Water Treatment Plant.
March 1983	FDA completed an investigation of contamination in Mississippi River fish in the St. Louis area. The report indicated the presence of organic contaminants in fish up to 150 miles south of the Sauget area, and concluded that the contaminants detected (chlorinated nitrobenzenes) were directly attributable to discharges in the Sauget area.
April 1983	Clean-up plan for dioxin-contaminated soils submitted and approved by IEPA/USEPA.
June 1983	IEPA ordered the excavation of underground tank owned by Bliss, situated on Clayton Chemical property. Tank found to be ruptured. Soil and waste samples collected by IEPA.
June 1983	USEPA FIT contractor initiated subsurface investigation at Site Q. Sixty-three of 112 organic compounds analyzed for detected in subsurface soil samples. 2,3,7,8-TCDD detected in two samples.
August 1983	Based on the results of previous sampling, IEPA ordered excavation of additional soil from excavation of Bliss underground tank.
October 1983	G & M retained by Monsanto to conduct a detailed hydrogeologic investigation of Monsanto property in Sauget, including Site R.

October 1983	IEPA received numerous complaints from area residents concerning contamination in Dead Creek.
May 1984	Wastes in lagoon area at Site O were uncovered by workers excavating a trench for a water line to the new treatment plant. Trench was covered, and water line was installed above ground. No reports of exposure-related illness resulting from this incident have been located.
July 1984	G & M initiated a hydrogeologic investigation at Site O to characterize the influence of the former sludge lagoons on area groundwater.
July 1984	Monsanto applied for a permit to construct a revetment along the bank of the Mississippi River at Site R. Revetment installed some time in 1985.
August 1984	Contaminated soils were encountered by workers at Site O during excavation for construction of transfer sewer. Soil sampling by private consultant revealed high concentrations of phenols and PAHs. No reports of exposure-related illness resulting from this incident have been located.
October 1984	IEPA conducted inspections at Site G and CS-B in order to determine scope of proposed cleanup at the sites. Samples from oily pits at Site G revealed a variety of organics.
December 1984	IEPA submitted HRS for Dead Creek and surrounding sites. Score of 29.23 was not accepted by USEPA due to lack of documentation.

December 1984	IEPA selected a contractor for a limited scope cleanup at Site G and CS-B. IEPA later reconsidered cleanup, and decided to delay activity until a detailed investigation of the area was completed.
December 1984	IEPA received an anonymous phone call indicating that it would be dangerous to excavate Site G due to the presence of underground toxic wastes.
January 1985	IEPA began procurement activities to select a consultant to perform an SI in the Sauget area.
March 1985	Illinois Attorney General's office reentered suit against Sauget & Co. Ordered final cover to be applied at Site Q and requested civil penalty.
June 1985	Petition from area residents sent to Illinois Governor James Thompson's office requesting cleanup of Dead Creek. "Clean Illinois" money appropriated for SI.
July 1985	IEPA selected consultant (E & E) to conduct SI at the 12 disposal sites and Dead Creek.
October 1985	E & E conducted preliminary geophysical investigations and topographic mapping at the DCP sites.
August 1986	E & E submitted proposed scope of work revisions directed toward HRS scoring to the IEPA. FS portion of the investigation postponed.
September 1986	Initial G & M report on hydrogeologic investigation for Monsanto properties submitted to IEPA. Report estimated load of 77 pounds per day of organic contaminants to river from Site R.

October 1986	E & E initiated field investigations at the DCP sites. Soil gas monitoring indicated widespread contamination at Area 1 sites.
November 1986	E & E soil sampling revealed extremely high concentrations of organics, particularly PCBs, in surficial soils at Site G.
December 1986	G & M completed report on investigation at Site O. Report outlined the extent of groundwater contamination attributable to the former sludge lagoons.
May 1987	USEPA emergency response investigation led to the construction of a fence around Site G, restricting access to the site. The fence was constructed by Monsanto under the supervision of USEPA.
October 1987	E & E completed field investigations at the DCP sites.
March 1988	E & E submitted first draft of SI report for IEPA review.

It must be noted that this chronology is not a complete list of activities at the DCP sites. An attempt was made to highlight significant investigation activities or occurrences at the sites, while omitting routine inspections and other less significant activities.

2.6.3 Historical Site Ownership

In order to develop a more accurate picture of the history of waste disposal activities at the DCP sites, a historical property search was conducted to determine the ownership of sites at the time disposal activities were occurring. Sites for which file material contained sufficient information on owners/operators were not researched. The

historical property search was focused around the Dead Creek area sites, including Sites G, H, I, and K. Disposal operations at these sites predated the enactment of regulatory controls, and as a result, no records are available concerning the owner/operator of the sites. Due to the large number of transactions for several properties, many records were incomplete or missing for certain dates of interest. However, property ownership in the period relevant to disposal activity was obtained for each of the sites in question. A summary of property ownership of the DCP sites relative to disposal operations is presented in Table 2-1.

2.7 WASTE CHARACTERIZATION

The majority of the DCP sites were used for the disposal of both general refuse and industrial wastes. Since many of the sites have been inactive for 15 years or more, a comprehensive list of wastes accepted at the sites is not available. Monsanto submitted inventories of waste material disposed of at Site R to IEPA on two occasions. These inventories are the only detailed listings of waste types for the DCP sites. Because Monsanto has a file policy to destroy records older than 5 years, complete information concerning waste types and volumes is not available. Waste treatment sludge was disposed of in the lagoons at Site O. Due to the nature of the influent to the Sauget Waste Water Treatment Plant (over 90% from area industries, with Monsanto being the largest single contributor), and the long history of contaminated effluent from the plant, it is likely that the sludge at Site O contained many of the same waste types listed on the inventories for Site R. Site P was a solid waste disposal facility permitted by the IEPA to accept only nonchemical waste from Monsanto. However, several IEPA inspection reports indicate that chemical wastes were disposed of at Site P. On one occasion, Monsanto was required to remove approximately 25 metal containers labeled phosphorus pentasulfide from the site. Site P also received a supplemental permit to accept metal-bearing filter cake waste from Edwin Cooper, Inc. (now Ethyl Corp.). Site Q also reportedly accepted chemical wastes, although no specific information is available concerning waste characteristics.

Table 2-1

PROPERTY OWNERS/OPERATORS DURING PERIOD OF DISPOSAL OPERATIONS

Site Desig.	Approx. Years of Operation*	Owner(s) at Time of Operation	Present Owner(s)	Source**
G	1950-1973	Leo and Louise Sauget-part (until 1966) Myrtle Hankins Present Cerro property-unknown	Cerro Copper Products Co. Wiese Engineering Co. Emily Hankins, Myrtle Hankins	Property search
H	1937-1957	Leo and Louise Sauget (1948)	J. D. Tolbird (Roger's Cartage Co.)	Property search
I	1937-1957	Leo and Louise Sauget (1948)	Cerro Copper Products Co.	Property search
J	1955	Sterling Steel Co.	St. Louis Steel Co. (Sterling Steel Foundry)	Property search, personal communication
K	1950-1973	Leo and Louise Sauget (1957)	Bank of Belleville (Trust property for Yvonne Sauget)	Property search
L	1971-1979	Waggoner Trucking Co. (Harold Waggoner)	Tony and Velma Lechner (Metro Construction Equipment Co.)	IEPA file, personal communication
M	1950-	H. H. Hall Construction Co.	Thomas Owen	Property search

Table 2-1 (Cont.)

Site Desig.	Approx. Years of Operation*	Owner(s) at Time of Operation	Present Owner(s)	Source**
N	1950-1962	H.M. Hall Construction Co.	H. M. Hall Construction Co.	Property search, personal communication
O	1967-1970	Village of Sauget	Village of Sauget	IEPA file, property search
P	1972-1984	Illinois Central Gulf R.R. (until 1979) Paul Sauget Union Electric Co.	Bank of Belleville for (Trust property for Paul Sauget) Union Electric Co.	IEPA file
Q	1962-1975	Cahokia Trust-Paul Sauget	Riverport Terminal & Fleetng Co. (leased to Pillsbury Co.)	IEPA file
R	1957-1974	Monsanto Chemical Co.	Monsanto Chemical Co.	IEPA file

* Where available, years of operation are based on file material.
If file information was not available, years were based on review of historical aerial photos.

** Property search was conducted at the St. Clair County Tax Assessor's office in Belleville.
Other sources include: IEPA file material with specific reference to property ownership
(correspondence, permit applications, enforcement documents), or personal communication with
present site owners or operators.

Source: Ecology and Environment, Inc. 1988.

Although very little information is available concerning the characteristics of waste material disposed of at the majority of the DCP sites, previous investigations and sampling have identified a wide variety of chemical compounds at the sites. Notifications were also submitted to the USEPA. These documents contain information on general waste types (e.g., organic, inorganic) and volumes, for several of the DCP sites, including Sites H, I, O, Q, and R. A partial list of waste types identified at the various project sites was prepared to highlight the similarity of waste types found at the different sites (see Table 2-2). The list is not a comprehensive catalog of all compounds identified at the sites.

2.8 PREVIOUS INVESTIGATIONS

As discussed previously in this report, site histories and previous investigations have been described in detail in a report titled "Description of Current Situation at the Dead Creek Project Sites" (see Appendix A). Although the Sauget area has been extensively studied, several of the project sites had not been studied previously. These include Sites H, J, K, and N (Site H was identified, but not specifically investigated, in the investigation outlined below).

As a result of several incidents involving contaminants in Dead Creek (CS-B), IEPA initiated a hydrogeologic investigation in 1980 to determine the source of contamination in the creek. The investigation included detailed sampling of the creek sediments and surface water, installing and sampling 12 monitoring wells, and drilling borings to characterize subsurface soils. The investigation revealed significant and widespread contamination in and around the northern portion of Dead Creek, and identified the present Area 1 sites as likely sources of groundwater contamination. The results of this investigation were presented in a report (St. John 1981) and are synopsized in the report in Appendix A.

In 1983, IEPA and a private consultant (Envirodyne Engineers, Inc.) conducted a joint investigation in an area to the north of the former sludge lagoons at Site O. This investigation was performed as a result of previous sampling conducted in the area by IEPA which showed high concentrations of PCBs in surficial soils. This investigation included

Table 2-2

PARTIAL LIST OF WASTE TYPES IDENTIFIED
AT THE DCP SITES

Chemical	Sites Where Chemicals Were Identified
aliphatic hydrocarbons	G, Q, R, CS-A, CS-B
chloroanilines	G, I, Q, R
chlorobenzenes	G, I, O, Q, R, CS-A, CS-B
chloronitrobenzenes	Q, R, CS-B
chlorophenols	G, I, L, O, Q, R, CS-B
dioxins/dibenzofurans	O, Q, R, CS-B
naphthalenes	Q, R, CS-B
PCBs	G, H, O, Q, R, CS-A, CS-B, CS-C
phenanthrene	G, O, Q
phenol	I, L, O, Q, R, CS-B
pyrene	G, O, Q

* No previous information or data was available for the following sites: H, J, K, and N.

Source: Ecology and Environment, Inc. 1988.

collecting 33 surface and subsurface soil samples, which were subsequently analyzed for PCBs and 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The results of this analysis samples showed significant PCB and 2,3,7,8-TCDD contamination throughout the area, and led to the removal and containment of approximately 2,800 cubic yards of contaminated soil. The results of this investigation are also included the report in Appendix A.

Also in 1983, USEPA Field Investigation Team (FIT) with E & E as the consultant conducted a subsurface investigation in the northern portion of Site Q as a result of an incident in which buried drums were unearthed during excavation activity. The study included a systematic geophysical investigation, followed by a drilling and sampling program to investigate possible subsurface contamination. The geophysical investigation identified the probable limits of landfilling and burial zones of relatively large concentrations of iron-bearing materials such as drums or car bodies. The drilling/sampling program consisted of drilling 18 test borings through the landfill, and collecting 35 soil samples for full priority pollutant analysis. The results of the investigation showed that 63 of the 112 organic compounds on the priority pollutant list were present in the subsurface samples. Twenty organic compounds were detected at concentrations exceeding 100 parts per million (ppm). In addition, 2,3,7,8-TCDD was detected in two samples. The investigation confirmed the presence of organic contaminants throughout the northern portion of Site Q, and substantiated reports of chemical waste disposal at the site. Results and data for this investigation can also be found in Appendix A.

In 1983, Monsanto retained G & M to conduct a hydrogeological investigation at several Monsanto properties, including Site R. The investigation included the installation and sampling of approximately 60 monitoring wells, a soil boring investigation, hydraulic conductivity testing, and water level measurements. G & M also did extensive file research on past groundwater use in the area. The G & M investigation delineated groundwater flow regimes and identified source areas of groundwater contamination. Using the data obtained during field investigations, G & M estimated contaminant loading to the Mississippi River at an average rate of 77 pounds per day of organics (Geraghty &

Miller 1986). G & M concluded that this loading is insignificant due to the dilution of constituents upon discharge to the river. G & M's procedures, results, and conclusions were presented in a report previously submitted to IEPA (Geraghty & Miller 1986).

G & M was also retained by the Sauget Sanitary Development and Research Association (SSDRA) in 1984 to perform an assessment of groundwater conditions at Site O. The investigation included the installation and sampling of 14 monitoring wells, collecting groundwater measurements, and drilling 12 soil borings. This investigation was conducted concurrently with the investigation of Monsanto property, which was described above. G & M identified two source areas that have impacted groundwater quality at Site O. The areas identified include the former sludge lagoons and an unlined pit located to the northeast of the lagoons. G & M also concluded that source areas to the east of the SSDRA property are probably contributing factors for groundwater contamination found at the site. The results of the G & M investigation on the SSDRA property were discussed in a report which was also submitted to IEPA (Geraghty & Miller 1986a).

Although E & E and IEPA do not necessarily agree with all of G & M's findings, the investigations indicate that both Site O and Site R have contributed to some degree to the contamination of various media in the Sauget area.

In addition to the investigations described above, IEPA and USEPA have collected samples from several of the DCP sites on numerous occasions. Sample results and other data obtained from these events are presented in the current situation report, which is attached as Appendix A.

3. REMEDIAL INVESTIGATION PROCEDURES

3.1 INTRODUCTION

This section presents the purpose, methods, and procedures of the DCP field activities, as outlined in the revised scope of work proposal submitted to the IEPA in August 1986. These field activities included geophysical investigations, soil gas monitoring, surface water and sediment sampling, surface and subsurface soil sampling, installation of monitoring wells, hydraulic conductivity testing, infiltration testing, groundwater sampling, and air sampling. E & E developed a Work Plan, Sampling Plan, and Quality Assurance Project Plan (QAPP), based on the original scope of work proposed by IEPA, in May 1986. These documents were supplemented with a proposal for a revised scope of work (submitted to IEPA in August 1986), which served as an addendum to the Work Plan; an addendum to the QAPP describing air sampling methods and analytical procedures; and a site-specific Health and Safety Plan. The procedures for all field investigations were governed by the QAPP and the addendum for air sampling. Geophysical surveys were conducted in October and December 1985. The remaining field investigations were conducted during the period from October 1986 to October 1987. All fieldwork was performed by E & E personnel or subcontractors under the direct supervision of E & E.

3.2 GEOPHYSICAL SURVEYS

Geophysical surveys, including magnetometry and electromagnetics (EM), were conducted at DCP Sites G, H, L, and a portion of Site J during October 1985. Geophysical survey procedures were governed by a

mini-QAPP and Work Plan, submitted to IEPA in October 1985. Investigations at Site G replaced those originally scheduled for the surface disposal area at Site J, because a visual inspection of the surface disposal area at Site J indicated unfavorable conditions for a magnetometry survey. The area was covered with metal-bearing slag and foundry sands, which would have prevented developing an accurate representation of subsurface conditions at the site. The originally proposed surveys at Site I were also not completed due to access restrictions imposed by Cerro Copper Products.

3.2.1 Electromagnetics Survey

The purpose of the EM study was to characterize subsurface materials and identify contaminant plumes at the sites surveyed. The EM technique measures the electrical conductivity of subsurface soils, rock, and groundwater. Subsurface conductivities are dependent on several factors, including soil moisture content, the thickness of soil and rock layers, and the presence of dissolved ions or other chemicals. Many contaminants will produce an increase in free ion concentration when introduced to soil or groundwater systems. An increase or decrease over background conductivity can reveal the presence of contaminants in soils and/or groundwater.

A Geonics Limited Model EM-34 EM conductivity meter was used for the surveys. The EM technique consists of inducing an electromagnetic current between two coils attached by a cable of a specific length. The transmitter coil generates a primary electromagnetic field, which passes through subsurface materials, generating a secondary electromagnetic field that is recorded in the receiver coil. The secondary magnetic field produces an output voltage which correlates to subsurface conductivity. Sampling depth of the EM meter is varied by changing the coil spacing and the orientation of the coils (e.g., a larger distance between coils allows for deeper penetration of the induced magnetic field).

EM surveys were conducted at Sites G, H, L, and J. Survey grids were laid out at each site using a compass and tape measure. Grid spacing varied, depending on the dimensions of the area being surveyed. At Site H, coil spacings of 10 and 20 meters, corresponding to nominal

sampling depths of 15 and 30 meters, respectively, were used. The remaining sites were surveyed using 10-meter coil spacing. Both horizontal and vertical coil orientations, allowing increased resolution of sounding points, were used at all sites surveyed. The EM meter was calibrated in background areas prior to conducting the surveys at each site.

3.2.2 Magnetometry Survey

The purpose of the magnetometry survey was to locate possible areas of ferrous materials such as buried steel drums, which would in turn enable more efficient placement of soil borings and monitoring wells. The magnetometry principle is based on measuring the intensity of the earth's magnetic field. The presence of ferrous materials creates local variations in the intensity of the magnetic field, allowing the detection of such materials as steel drums. The magnetic response measured by a magnetometer is proportional to the mass of ferrous materials, and is also related to the distance to the material, the degree of degradation (corrosion) of the material, and the orientation of the material.

The magnetometry survey was subcontracted to Technos, Inc., of Miami, Florida. Technos used a fluxgate gradiometer magnetometer (MAG) with continuous measurement capability. This system provides a detailed search over the entire length of a grid line, and allows operation in areas where other magnetometer systems would fail due to surface "noise" (such as fences or other ferrous materials on the surface). This is possible because the sensors on the MAG minimize the presence of objects on the horizon while maintaining full sensitivity for buried objects.

MAG surveys were conducted at Sites G, H, L, and J. Survey grids were laid out at each site in similar fashion to those used for the EM work. The MAG was calibrated in background areas prior to the field surveys at each site. The unit consisted of two vertical fluxgate sensors which provided vertical gradient measurement of the magnetic field with a maximum sensitivity of 0.3 gammas per foot. Data from the MAG were continuously recorded on a strip chart recorder along each survey line, and reference marks were made on the chart for mapping

purposes. Technos submitted a report, describing the procedures and results of the survey, to E & E in December 1985.

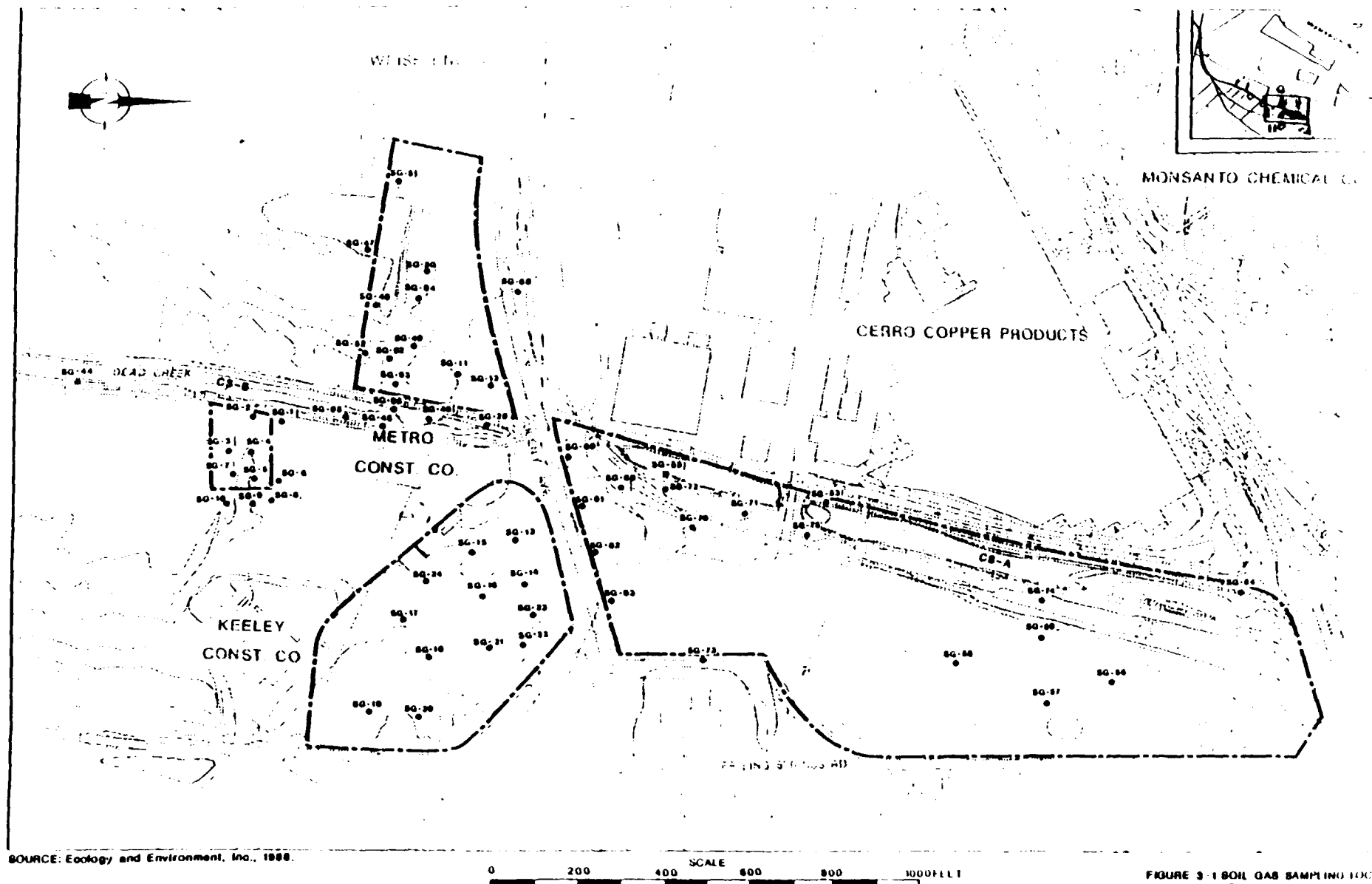
The results of both geophysical surveys are discussed in Section 4.1.1 of this report.

3.3 SOIL GAS SURVEY

Previous investigations at the DCP sites showed the presence of a wide range of organic contaminants in various media (soil, groundwater) throughout the project area. Several volatile organic compounds (VOCs) were among the contaminants previously detected at the sites. Due to the areal extent of contamination found in the DCP area, a soil gas survey was conducted to identify significantly contaminated areas (using volatile organics as an indicator), identify the boundaries of the former excavations, and determine migration routes of contaminants. The results of the surveys enabled the more efficient placement of soil borings and monitoring wells. The survey was conducted during October and November 1986.

Because the distribution of contaminants at the Area 2 sites had been fairly well-documented, the soil gas survey was centered around the Area 1 sites and the peripheral sites. A total of 96 locations were sampled, including: 12 locations at Site G, 12 at Site H, 16 at Site I, 12 at Site J, 8 at Site K, 10 at Site L, 6 at Site M, 8 at Site N, 3 in CS-A, 6 in CS-B, and 3 in CS-C. Soil gas sample locations for the Area 1 sites (including CS-A and the northern portion of CS-B) are shown in Figure 3-1. Sample locations for Sites J and K are shown in Figures 3-2 and 3-3, respectively, and sample locations for the southern portion of CS-B, CS-C, Site M, and Site N are shown in Figure 3-4.

Sampling locations at Sites G, H, and L were selected using the grid systems previously developed for the geophysical investigations at the sites. The remaining sites were sampled randomly, with an initial perimeter survey to locate "hot spots," followed by the selection of additional locations radiating from these hot spots to determine the areal extent of contamination at the sites. Background data was collected for each site at locations selected in the field. The background data served as a baseline for each site, and was compared with the remaining sample locations at each site.



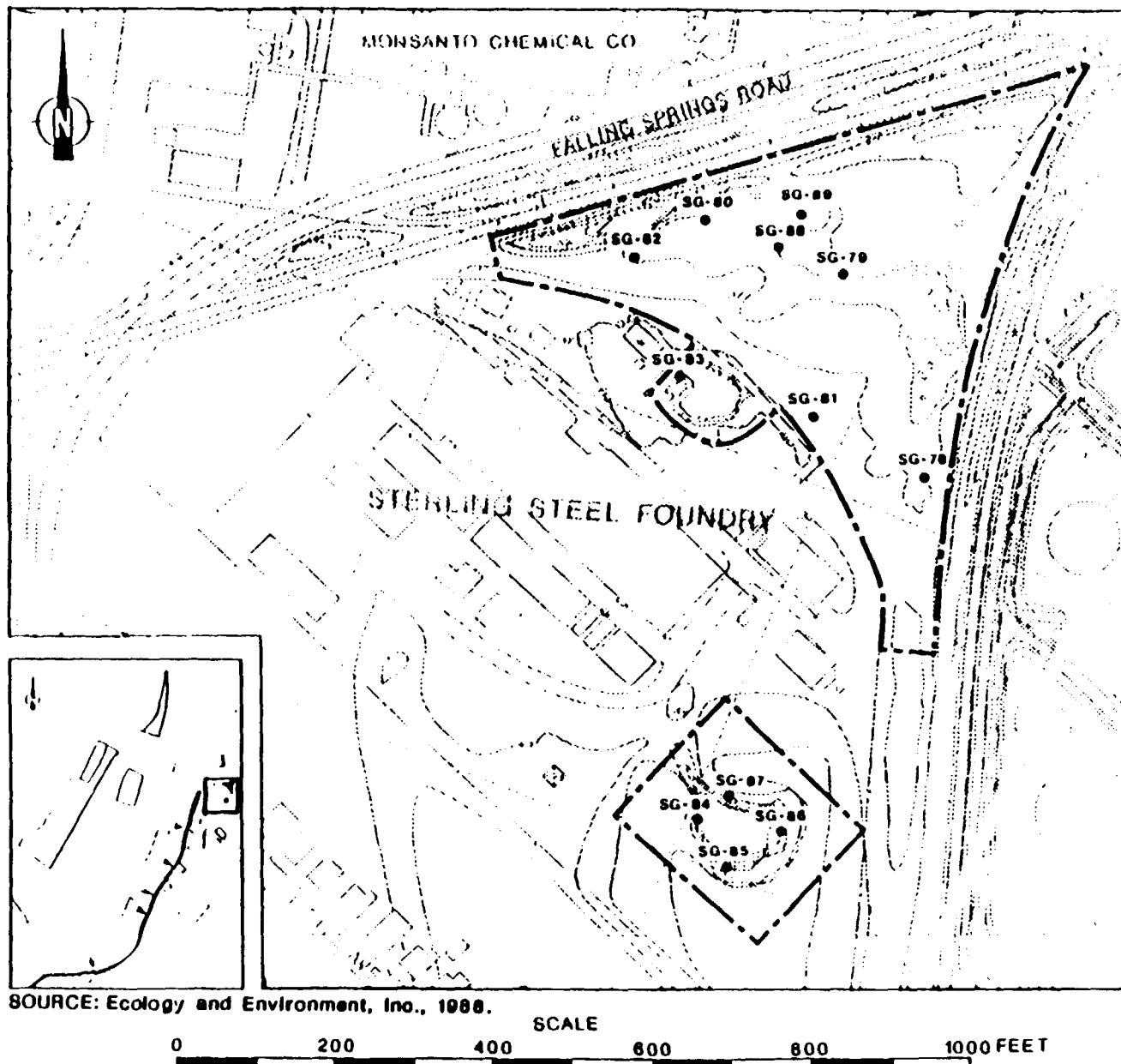
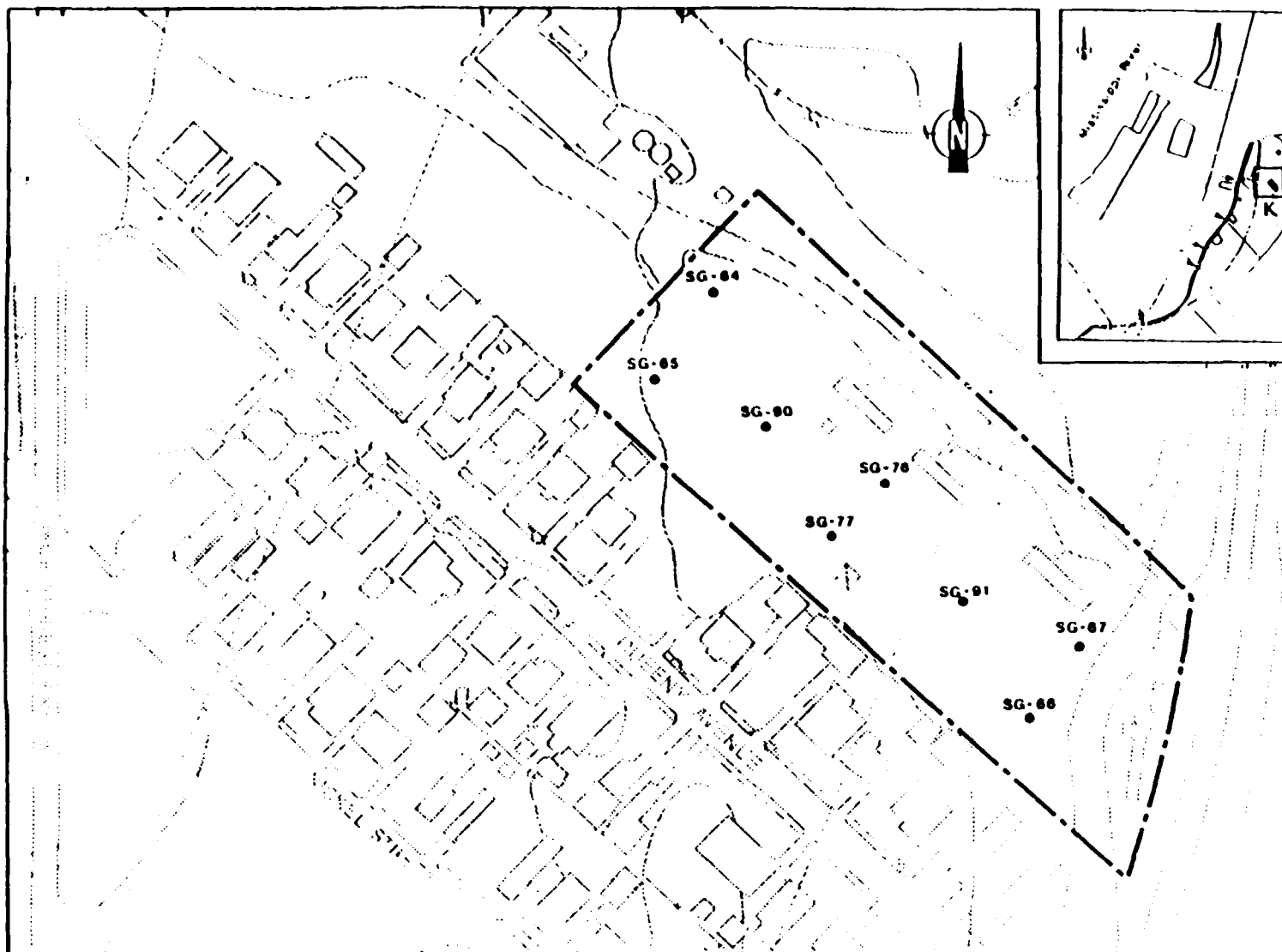


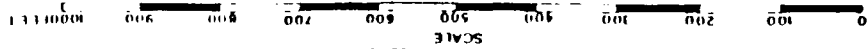
FIGURE 3-2 SOIL GAS SAMPLING LOCATIONS AT SITE J



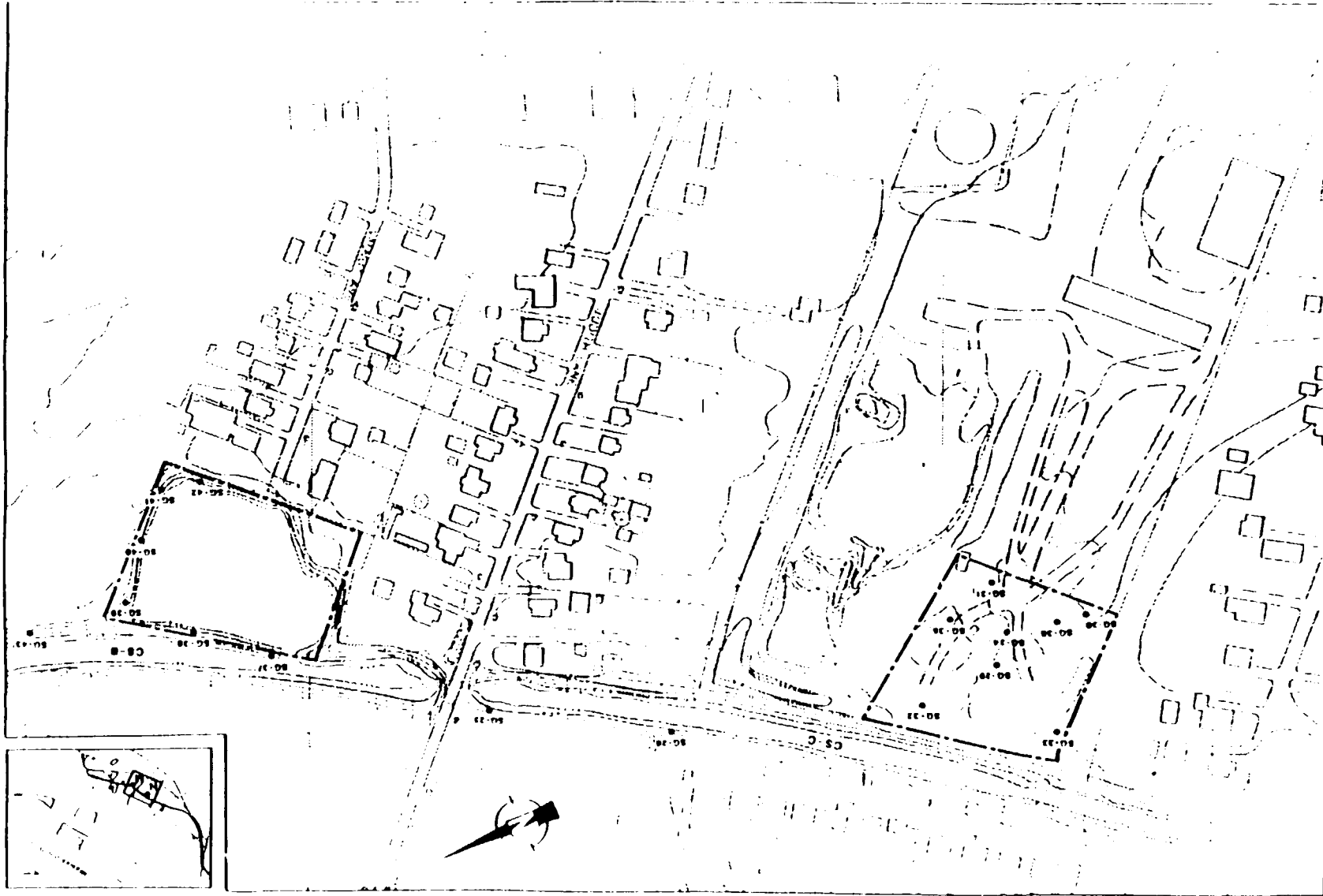
SOURCE: Ecology and Environment, Inc., 1988.



FIGURE 3-3 SOIL GAS SAMPLING LOCATIONS AT SITE K



SOURCE: Ecology and Environment, Inc., 1988



The primary equipment used for the soil gas survey consisted of 5/8-inch outside diameter (OD) stainless steel well points and rod sections. The well points were 6 inches long, and had four narrow, vertically oriented slots to permit gas flow into the point. Each rod section was 2.5 feet long, and had a stainless steel threaded end to allow flush connection to the well points. This sampling assembly was driven into the ground to the desired sample depth using a special cylindrical hammer. The above-ground end of the sampling assembly was fitted with a Teflon ferrule reducer, which allowed 1/4-inch inside diameter (ID) Teflon tubing to be attached directly to the well point. This tubing enabled the soil gas to be drawn from the well point directly to an analyzer. A Foxboro Corporation organic vapor analyzer (OVA) Model-128 was used to draw and analyze the samples. The OVA has a pumping rate of approximately 2 liters per minute, which was found to be sufficient to draw samples from shallow depths. For analytical purposes, the OVA utilizes the principle of hydrogen flame ionization to detect and measure organic vapors.

Sampling was performed by initially driving each well point to a depth of 3 feet, and attaching the Teflon connector and tubing. This assembly was then allowed to equilibrate for several minutes. Following equilibration, vadose zone air was withdrawn from the well point by the OVA air pump, and analyzed (with the instrument in the survey mode) for total VOCs using the OVA detector system. If the air pump on the OVA was stressed (indicating well point blockage), Grade D or E compressed air was blown through the sampling assembly to clear the well point. If organic vapors were detected, the OVA probe was left attached to the tubing until a concentration peak was achieved. After collecting an initial reading, the sampling assembly was again allowed to equilibrate. A replicate analysis was then performed at each location to verify OVA readings.

In addition to background and replicate analysis, two other procedures were followed to maintain quality assurance of the soil gas data. The first procedure involved using an activated carbon filter, attached to the OVA probe, to check for the presence of methane. The second procedure consisted of collecting a vadose zone air sample in a gas sampling bag using a method slightly modified from that described

above, and running a more detailed analysis of the sample with a bench-top gas chromatograph (GC). This procedure was used primarily as a confidence check for the survey procedure described above. Analysis of the gas bag samples was limited to peak identification on the GC strip chart. A total of six samples was collected and analyzed using this procedure.

Results of the soil gas survey are presented and discussed in Section 4.2.1 of this report.

3.4 SURFACE WATER AND SEDIMENT SAMPLING

Surface water and sediment samples were collected from Dead Creek and Site M for the purpose of determining the distribution of contaminants in these areas. Thirteen surface water samples, including three quality control (QC) samples, were collected during the investigation. Samples were collected from upstream and downstream locations in Creek Sectors A, B, C, and D, and from two locations in Site M. Twenty-three sediment samples, including four QC samples, were collected. Sediment samples were collected from two separate depth intervals at upstream and downstream locations in Creek Sectors A, B, C, and D, and from three locations at Site M. Eight additional sediment samples, including two field QC samples, were collected from CS-B (3 samples), CS-C (2), and CS-A (1) for dioxin analysis.

The dates of collection and locations of the surface water and sediment samples are listed in Table 3-1, and sample locations are shown in Figure 3-5. Except for those samples collected for dioxin analysis, all samples were submitted to E & E's Analytical Services Center (ASC) in Cheektovaga, New York, for analysis of all Hazardous Substance List (HSL) compounds, plus metals and cyanide (see Table 3-2). Dioxin analysis was performed by Envirodyne Engineers, Inc. (EEI) in St. Louis, Missouri. All surface water and sediment samples were collected during the week of November 3, 1986.

Surface water samples were collected using wide-mouth glass jars, dedicated for each sample location in order to minimize cross-contamination. The jar was initially dipped into the creek and rinsed three times at each sample location. The jar was then used to transfer the sample into 1/2-gallon glass bottles, 40-mL glass vials, and 1-liter

Table 3-1

SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS

Sample Number	Date Collected	Location of Sample	Depth (ft)	Comments
SD-01*	11-5-86	CS-B, 410' South of Metro Bldg.	0-0.5	strong odor, oily
SD-02*	11-5-86	CS-B, Adj. North end Metro Bldg.	0-0.5	strong odor, oily
SD-05*	11-5-86	CS-B, 150' North of Judith Lane	0-0.5	
SD-06*	11-5-86	CS-B, 150' North of Judith Lane	0-0.5	duplicate of SD-05
SD-07*	11-5-86	CS-C, 25' North of Cahokia St.	0-0.5	
SD-08*	11-5-86	CS-C, 25' North of Cahokia St.	0-0.5	
SD-09*	11-5-86	CS-D, 35' South of Cahokia St.	0-0.5	
SD-10*	11-5-86	Field Blank		blank soil
SD-13	11-5-86	CS-B, Adj. North end Metro Bldg.	0-0.5	strong odor, oily
SD-14	11-5-86	CS-B, Adj. North end Metro Bldg.	2-3	
SD-15	11-5-86	Site M - At cut-through	0-0.5	
SD-16	11-5-86	Site M - Northeast corner	0-0.5	
SD-17	11-5-86	Site M - North central	0-0.5	
SD-18	11-5-86	CS-B, Adj. North end Metro Bldg.	0-0.5	
SD-19	11-5-86	CS-B, 150' North of Judith Lane	0-0.5	
SD-20	11-5-86	CS-B, 150' North of Judith Lane	1.5-2	
SD-21	11-5-86	CS-C, 25' South of Judith Lane	0-0.5	
SD-22	11-5-86	CS-C, 25' South of Judith Lane	2-2.5	
SD-23	11-5-86	CS-C, 35' North of Cahokia St.	0-0.5	
SD-24	11-5-86	CS-C, 35' North of Cahokia St.	2-2.5	
SD-25	11-5-86	CS-D, 35' South of Cahokia St.	0-0.5	
SD-26	11-5-86	CS-D, 35' South of Cahokia St.	1.5-2	
SD-27	11-5-86	CS-D, 25' South of Kinder St.	0-0.5	
SD-28	11-5-86	CS-D, 25' South of Kinder St.	1.5-2	
SD-29	11-5-86	Field Blank		blank soil

Table 3-1 (Cont.)

Sample Number	Date Collected	Location of Sample	Depth (ft)	Comments
SD-31	11-6-86	Field Blank		blank soil
SD-32	11-6-86	Field Blank		blank soil
SD-33	11-6-86	CS-A, North Pond (composite)	0-0.5	
SD-34	11-6-86	CS-A, North Pond (composite)	0-0.5	duplicate of SD-33
SD-35	11-6-86	CS-A, South Pond (composite)	0-0.5	
SD-36	11-6-86	CS-A, South Pond (composite)	1.5-2	
SW-01	11-5-86	Field Blank		deionized water blank
SW-02	11-5-86	Site M, At cut-through		
SW-03	11-5-86	Site M, Northeast corner		
SW-04	11-5-86	CS-B, Adj. North end Metro Bldg.		
SW-05	11-5-86	CS-B, 150' North of Judith Lane		
SW-06	11-5-86	CS-B, 150' North of Judith Lane		duplicate of SW-05
SW-07	11-5-86	CS-C, 70' South of Judith Lane		
SW-08	11-5-86	CS-C, 25' North of Cahokia St.		
SW-09	11-5-86	CS-D, 50' South of Cahokia St.		
SW-10	11-5-86	CS-D, 25' South of Kinder St.		
SW-11	11-6-86	Field Blank		deionized water blank
SW-12	11-6-86	CS-A, North Pond (composite)		high oil content
SW-13	11-6-86	CS-A, South Pond (composite)		

SD Sediment sample.

SW Surface water sample.

- Samples submitted to Envirodyne Engineers, Inc. (EEI) for dioxin analysis. All remaining samples submitted to E & E's ASC for analysis of HSL compounds, plus metals and cyanide.

Source: Ecology and Environment, Inc. 1988.

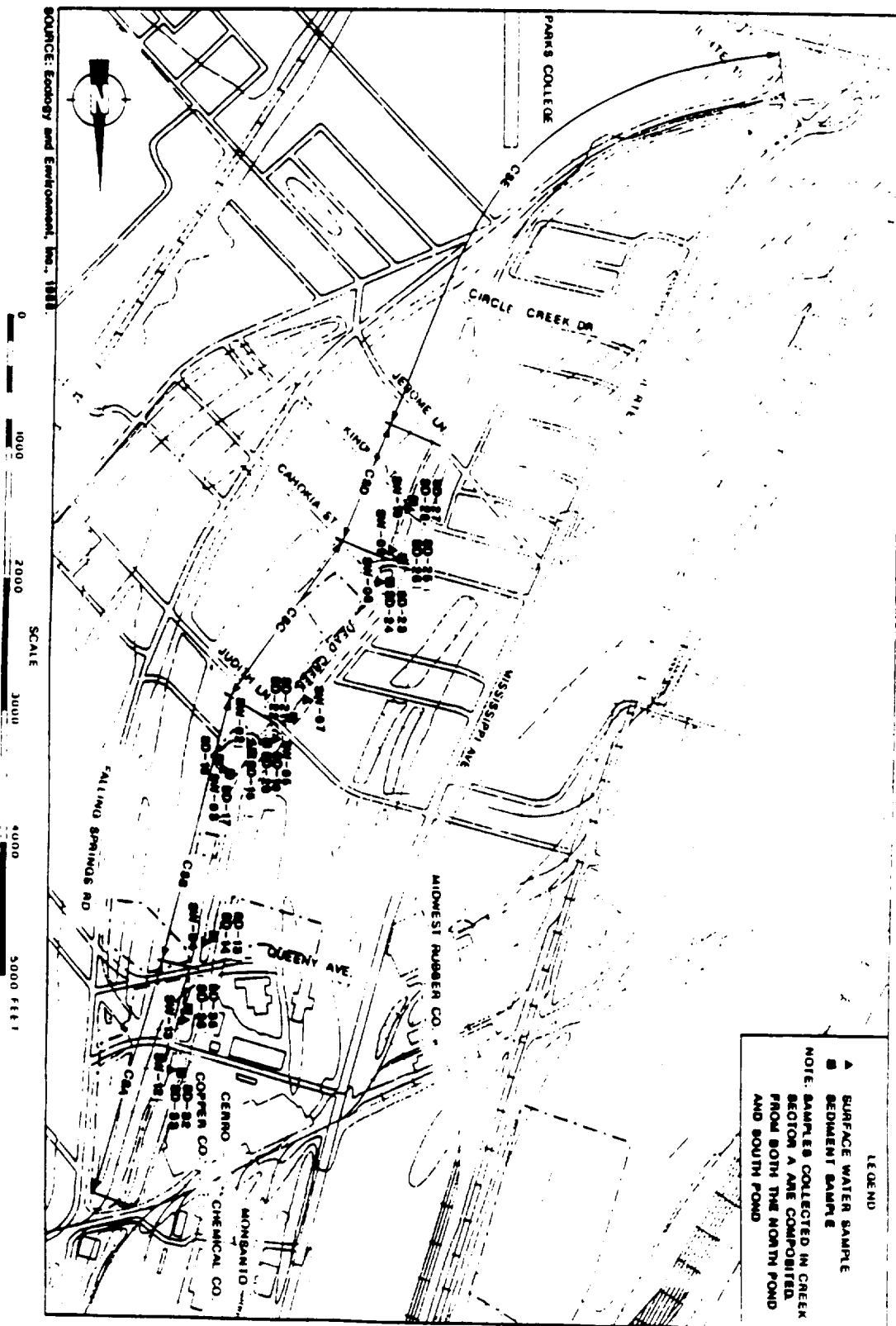


Table 3-2

ORGANIC AND INORGANIC PARAMETERS LIST

<u>Semivolatiles</u>	<u>Semivolatiles (Cont.)</u>	<u>Volatiles (Cont.)</u>	<u>Inorganics</u>
2,4,6-trichlorophenol	bis(2-ethylhexyl)phthalate	ethylbenzene	aluminum
p-chloro-m-cresol	benzyl butyl phthalate	methylene chloride	chromium
2-chlorophenol	di-n-butyl phthalate	chloromethane	barium
2,4-dichlorophenol	di-n-octyl phthalate	bromomethane	beryllium
2,4-dimethylphenol	diethyl phthalate	bromoform	cobalt
2-nitrophenol	dimethyl phthalate	bromodichloromethane	copper
4-nitrophenol	benzo(a)anthracene	chlorodibromomethane	iron
2,4-dinitrophenol	benzo(a)pyrene	tetrachloroethene	nickel
4,6-dinitro-2-methylphenol	benzo(b)fluoranthene	toluene	manganese
pentachlorophenol	benzo(k)fluoranthene	trichloroethene	boron
phenol	chrysene	vinyl chloride	vanadium
benzoic acid	acenaphthylene	acetone	arsenic
2-methylphenol	anthracene	2-butanone	antimony
3-methylphenol	benzo(g,h,i)perylene	carbon disulfide	selenium
4-methylphenol	fluorene	2-hexanone	thallium
2,4,5-trichlorophenol	phenanthrene	4-methyl-2-pentanone	mercury
acenaphthene	dibenzo(a,h)anthracene	styrene	tin
benzidine	indeno(1,2,3-c,d)pyrene	vinyl acetate	cadmium
1,2,4-trichlorobenzene	pyrene	xylene	lead
hexachlorobenzene	aniline		cyanide
hexachloroethane	benzyl alcohol	<u>Pesticides/PCBs</u>	
bis(2-chloroethyl)ether	4-chloroaniline	aldrin	
2-chloronaphthalene	dibenzofuran	dieldrin	
1,2-dichlorobenzene	2-methylnaphthalene	chlordan	
1,3-dichlorobenzene	2-nitroaniline	4,4'-DDT	
1,4-dichlorobenzene	4-nitroaniline	4,4'-DDE	
3,3'-dichlorobenzidine		4,4'-DDD	
2,4-dinitrotoluene	<u>Volatiles</u>	alpha-endosulfan	
2,6-dinitrotoluene	acrolein	beta-endosulfan	
1,2-diphenylhydrazine	acrylonitrile	endosulfan sulfate	
fluoranthene	benzene	endrin	
4-chlorophenyl phenyl ether	carbon tetrachloride	endrin aldehyde	
4-bromophenyl phenyl ether	chlorobenzene	heptachlor	
bis(2-chloroisopropyl)ether	1,2-dichloroethane	heptachlor epoxide	
bis(2-chloroethoxy)methane	1,1,1-trichloroethane	alpha-BHC	
hexachlorobutadiene	1,1-dichloroethane	beta-BHC	
hexachlorocyclopentadiene	1,1,2-trichloroethane	gamma-BHC	
isophorone	1,1,2,2-tetrachloroethane	delta-BHC	
naphthalene	chloroethane	Aroclor-1242	
nitrobenzene	2-chloroethylvinyl ether	Aroclor-1254	
N-nitrosodiphenylamine	chloroform	Aroclor-1221	
N-nitrosodipropylamine	1,1-dichloroethene	Aroclor-1232	
	trans-1,2-dichloroethene	Aroclor-1248	
	1,2-dichloropropene	Aroclor-1260	
	trans-1,3-dichloropropene	Aroclor-1016	
	cis-1,3-dichloropropene	toxaphene	

plastic bottles. The temperature, pH, and specific conductivity of the water was measured in the field.

Surface sediment samples were collected using stainless steel coring tools. In order to minimize cross-contamination between sample locations, a dedicated coring tool was used at each location. Samples were cored from the surface to a depth of 6 inches, and then transferred to 8-ounce wide-mouth glass jars. Subsurface sediment samples were collected using a hand-held bucket auger and stainless steel utensils. The bucket auger was used to core a hole to the desired sample depth, and a sample was collected. A core was then removed from the center of the bucket, and transferred to sample jars using the stainless utensils. The bucket auger was decontaminated between sample locations using the following procedure:

- Scrub with brushes in trisodium phosphate solution,
- Rinse with deionized water,
- Rinse with acetone,
- Rinse with hexane,
- Rinse with acetone, and
- Rinse with deionized water.

Quality assurance/quality control procedures (QA/QC) for the sampling were governed by the project QAPP. Surface water and sediment blank and duplicate samples were submitted as directed in the QAPP. Chain-of-custody and record-keeping procedures were also followed as described in the QAPP.

The analytical results for surface water and sediment samples are presented and discussed in Section 4.2.2 of this report.

3.5 SURFACE SOIL SAMPLING

Although the original scope of work called for surface soil sampling at several of the DCP sites, initial site visits and a review of available file material indicated that surficial wastes were probably present only at Sites G and J. For this reason, surface soil samples were collected only at Sites G and J, as outlined in the proposal to implement a revised scope of work, submitted to IEPA in August 1986.

The purpose of the surface soil sampling was to characterize waste types present and define the overall extent of surface contamination at the sites. Forty-eight surface soil samples, including seven QC samples, were collected and submitted to the ASC for analysis. Sampling was conducted during the week of November 10, 1986.

A grid with 50-foot intervals was staked out at Site G prior to sample collection. This grid was constructed using a compass and tape measures. A total of 74 sampling points, or grid sections, were sampled. The grid pattern used for surface soil sampling at Site G is shown in Figure 3-6. Grid sections were sampled by collecting three subsamples from each section, and compositing the subsamples in order to provide a representative sample for each grid section. Subsamples were collected using a dedicated stainless steel coring tool for each grid section. Compositing was done by thoroughly mixing subsamples in stainless steel bowls prior to placement in 8-ounce jars. Dedicated stainless steel tools were used to mix and transfer the samples. The 74 samples were then screened in the field using the procedure described below. The field screening procedure was used to reduce the number of samples requiring detailed laboratory analysis. Following the field screening, a total of 39 samples, plus six QC samples, was selected for analysis of HSL compounds as well as metals and cyanide (see Table 3-2). A summary of surface soil sample locations selected for analysis from Site G is presented in Table 3-3.

In addition to the surface soil sampling described above for Site G, two additional composite samples were collected for dioxin analysis. One sample was collected from a ridge in the southern portion of the site (grid sections B3 through F3) along which several corroded drums were observed, and the second sample was composited from areas around two oily pits in the northwest corner of the site (grid sections A7, A8, B6, B7, B8). The samples were collected and composited in the same fashion as described above.

Three surface soil samples, including one field QC sample, were collected from Site J. One sample was collected from the surface disposal area northeast of the foundry buildings, and the other sample was collected immediately southeast of a large pit in the southeast corner of the property. Samples were collected to a depth of 6 inches below



FIGURE 3-6 GRID SECTION DESIGNATIONS FOR SURFACE SOIL SAMPLING AT SITE G

Table 3-3

SURFACE SOIL SAMPLE LOCATIONS

Sample Number	Date Sampled	Sample Location	Comments
SS-01	11-10-86	Site G, Grid C1	
SS-02	11-10-86	Site G, Grid G1	
SS-03	11-11-86	Site G, Grid B2	
SS-04	11-11-86	Site G, Grid E2	
SS-05	11-11-86	Site G, Grid H2	
SS-06	11-11-86	Site G, Grid H2	duplicate of SS-05
SS-07	11-11-86	Site G, Grid I2	
SS-08	11-11-86	Site G, Grid J2	
SS-09	11-11-86	Site G, Grid A3	
SS-10	11-11-86	Site G, Grid B3	
SS-11	11-11-86	Site G, Grid C3	
SS-12	11-11-86	Site G, Grid D3	
SS-13	11-11-86	Site G, Grid E3	
SS-14	11-11-86	Site G, Grid F3	
SS-15	11-11-86	Site G, Grid G3	
SS-16	11-11-86	Site G, Grid G3	duplicate of SS-15
SS-17	11-11-86	Site G, Grid H3	
SS-18	11-11-86	Site G, Grid A4	
SS-19	11-11-86	Site G, Grid B4	
SS-20	11-11-86	Site G, Grid C4	
SS-21	11-11-86	Site G, Grid D4	
SS-22	11-11-86	Site G, Grid E4	
SS-23	11-11-86	Site G, Grid F4	
SS-24	11-11-86	Site G, Grid G4	
SS-25	11-11-86	Site G, Grid G4	duplicate of SS-24
SS-26	11-11-86	Site G, Grid H4	
SS-27	11-11-86	Site G, Grid I4	
SS-28	11-11-86	Site G, Grid J4	
SS-29	11-11-86	Site G, Grid A5	
SS-30	11-11-86	Site G, Grid B5	
SS-31	11-11-86	Site G, Grid B5	duplicate of SS-30
SS-32	11-11-86	Site G, Grid C5	
SS-33	11-12-86	Site G, Grid D5	
SS-34	11-12-86	Site G, Grid E5	
SS-35	11-12-87	Site G, Grid F5	
SS-36	11-12-87	Site G, Grid G5	
SS-37	11-12-87	Site G, Grid H5	
SS-38	11-12-87	Site G, Grid A6	
SS-39	11-12-87	Site G, Grid B6	
SS-40	11-12-87	Site G, Grid C6	
SS-41	11-12-87	Site G, Grid D6	
SS-42	11-12-87	Site G, Grid F6	
SS-43	11-12-87	Site G, Grid B7	

Table 3-3 (Cont.)

Sample Number	Date Sampled	Sample Location	Comments
SS-44	11-13-86	Field Blank*	Blank soil
SS-45	11-11-86	Field Blank*	Blank soil
SS-46	11-13-86	Site J, southeast of pit	
SS-47	11-13-86	Site J, surface disposal area	
SS-48	11-13-86	Site J, surface disposal area	duplicate of SS-47

* Field blanks consisted of soil from an undisturbed area in a background location to the east of the project area.

Source: Ecology and Environment, Inc. 1988.

ground surface using dedicated stainless steel coring tools.

As discussed above, a field analytical screening procedure was employed to reduce the number of samples requiring detailed laboratory analysis. This procedure consisted of initially placing a small amount (approximately 3 to 5 tablespoons) of sample from the composite sample container into a gas washing bottle. The material in the gas washing bottle was then heated to a temperature of approximately 180° F. An OVA was subsequently connected to the gas washing bottle with Teflon tubing, and measurements were collected (with the OVA in the survey mode) at 30-second intervals until a concentration peak was achieved. An activated charcoal filter was attached to the OVA probe to check for the presence of methane. Prior to collecting readings from the gas washing bottle, background interference was accounted for by zeroing the OVA readout using the calibration adjust knob. Between uses, the gas washing bottles were cleaned using brushes and a trisodium phosphate solution, and dried using D-quality compressed air.

Surface soil sampling procedures, QA/QC, and subsequent chemical analysis were governed by the QAPP and sampling plan developed for the project. The submittal of blank and duplicate samples, chain-of-custody procedures, and record-keeping procedures were followed as described in the QAPP.

The analytical results of the surface soil sampling investigation are presented and discussed in Section 4.2.3 of this report.

3.6 HYDROGEOLOGIC INVESTIGATION

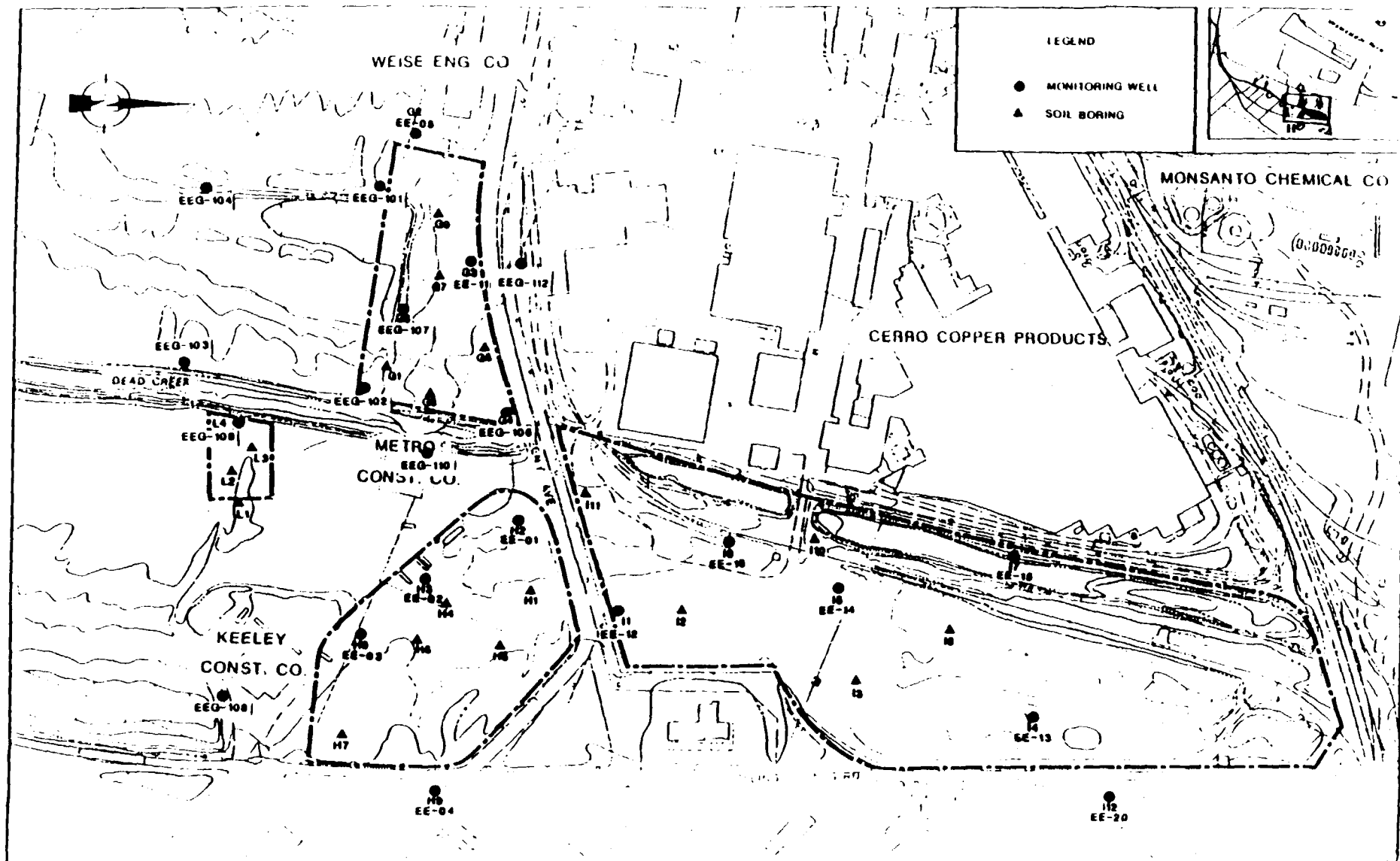
The primary objective of the hydrogeologic investigation was to provide a preliminary database for evaluating the groundwater quality, subsurface soil conditions, and groundwater flow regime at the DCP sites. Field investigation tasks consisted of subsurface soil sampling, monitoring well installation, well development, hydraulic conductivity (slug) testing of selected wells, and water level measurements. The drilling and installation of wells was subcontracted to Fox Drilling, Inc., of Itasca, Illinois, and was performed during the period December 11, 1986 to March 3, 1987. Slug tests were conducted by E & E personnel on May 11 through 13, 1987. Water level data were also collected by E & E personnel on March 26, May 12, and October 1, 1987.

The following sections detail procedures utilized during the hydrogeologic investigation.

3.6.1 Subsurface Drilling and Sampling

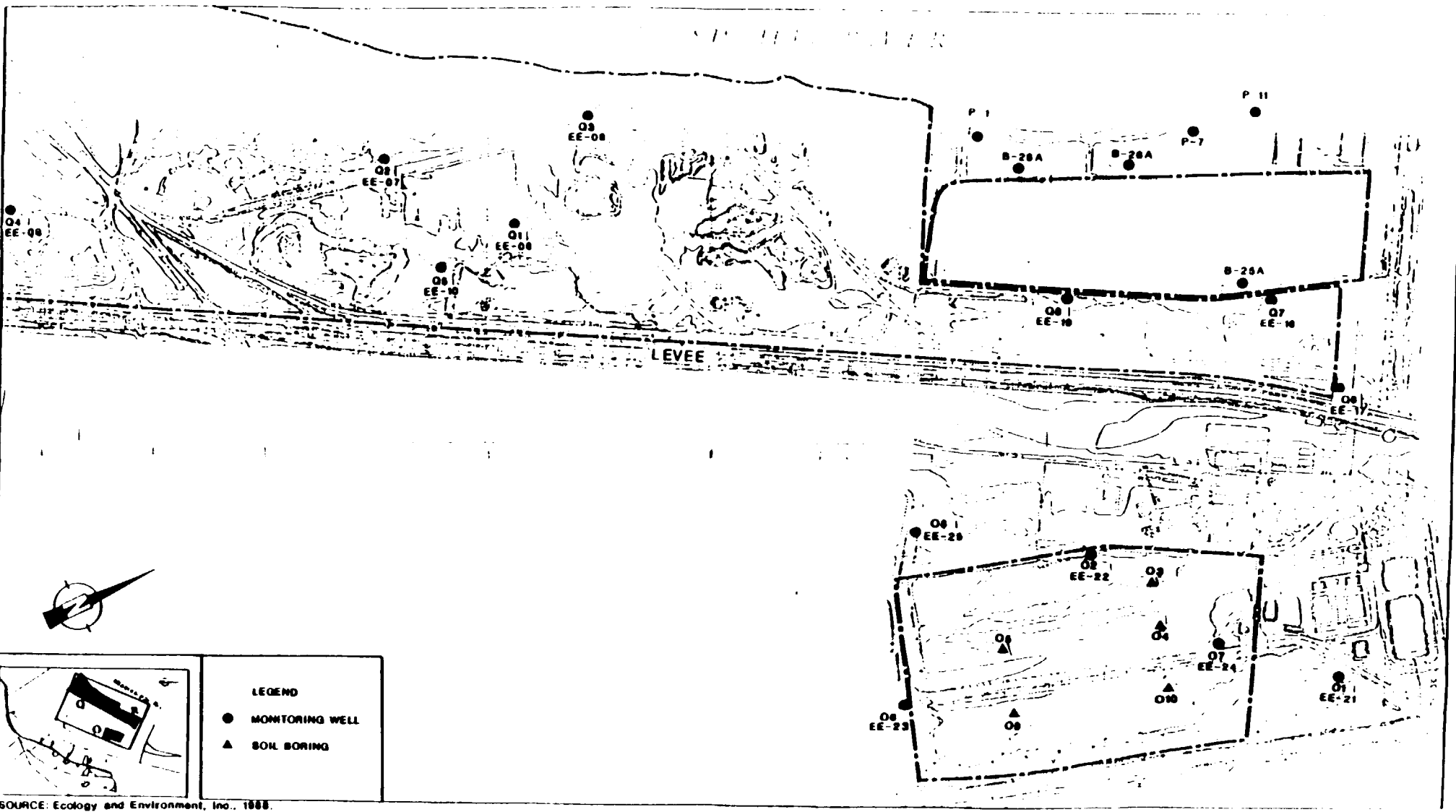
Seventy-one soil borings were drilled to evaluate the hydrogeologic conditions at the DCP sites. These sites included: Sites G, H, I, and L in Area 1; Sites O, Q, and R in Area 2; and peripheral sites J, K, N, and P. Monitoring wells were installed in 35 of these borings in Areas 1 and 2. The locations of soil borings and monitoring wells are shown on Figures 3-7 through 3-12. Soil borings were numbered with the letter of the site at which the boring was drilled, followed by a number indicating the sequence of drilling. Borings that developed into monitoring wells were also designated with an "EE" (indicating an E & E-drilled well) followed by a number indicating the sequential order of well installation.. Some IEPA wells in Area 1 were replaced during this investigation. Original designations for these wells were retained and the prefix "EE" was added to the number of each well replaced.

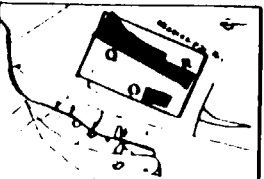
Soil borings ranged in depth from 14 to 50 feet. In general, borings were advanced through the surficial fine-grained silt, clay, and silty sand deposits until the silt-free, fine- to medium-grained sands of the lower Cahokia/upper Henry formations were encountered. All monitoring wells were screened in this material, typically at a depth of 10 to 20 feet below the water table. Table 3-4 lists the depths of all soil borings and monitoring wells completed during this investigation. Soil borings which were not developed into monitoring wells were tremie-grouted to the surface using a bentonite/cement grout. In borings that extended below waste materials, that portion of the boring below the waste was plugged with a thick bentonite slurry and/or bentonite grout prior to retracting the auger which was used as temporary casing. When voids in the waste zone prevented grouting to the surface, drill cuttings, silica sand, and grout were used to backfill the boring. In addition, a 3- to 5-foot cement plug was installed in soil borings to prevent surface run-off from infiltrating the boring. Drill cuttings and drilling muds that remained at the completion of drilling were drummed for future disposal.



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 3-7 MONITORING WELL AND BORING LOCATIONS AT AREA 1





LEGEND

● MONITORING WELL

▲ SOIL BORING

SOURCE: Ecology and Environment, Inc., 1988.

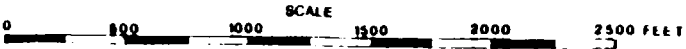
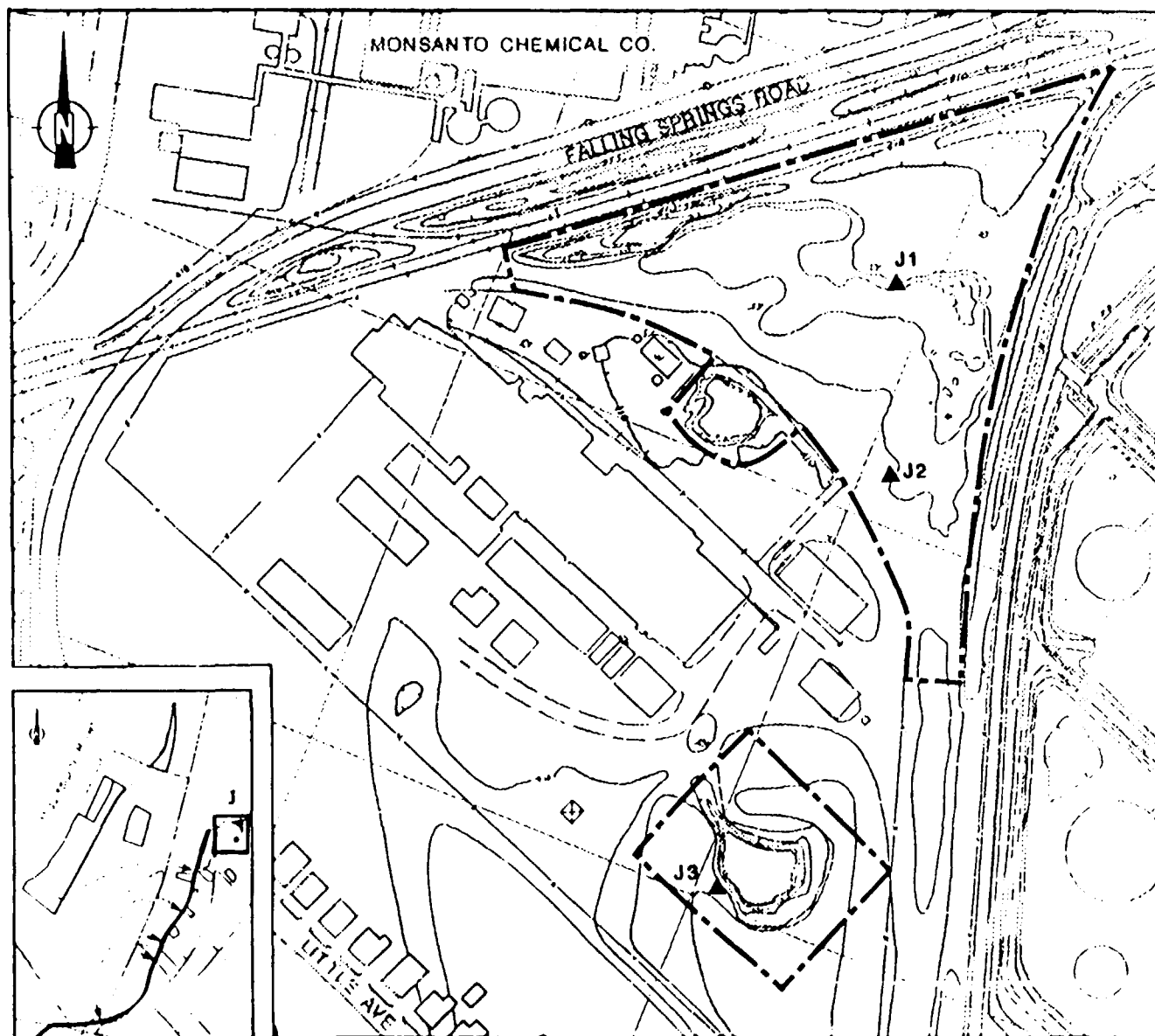


FIGURE 3-8 MONITORING WELL AND BORING LOCATIONS AT AREA 2



SOURCE: Ecology and Environment, Inc., 1988.

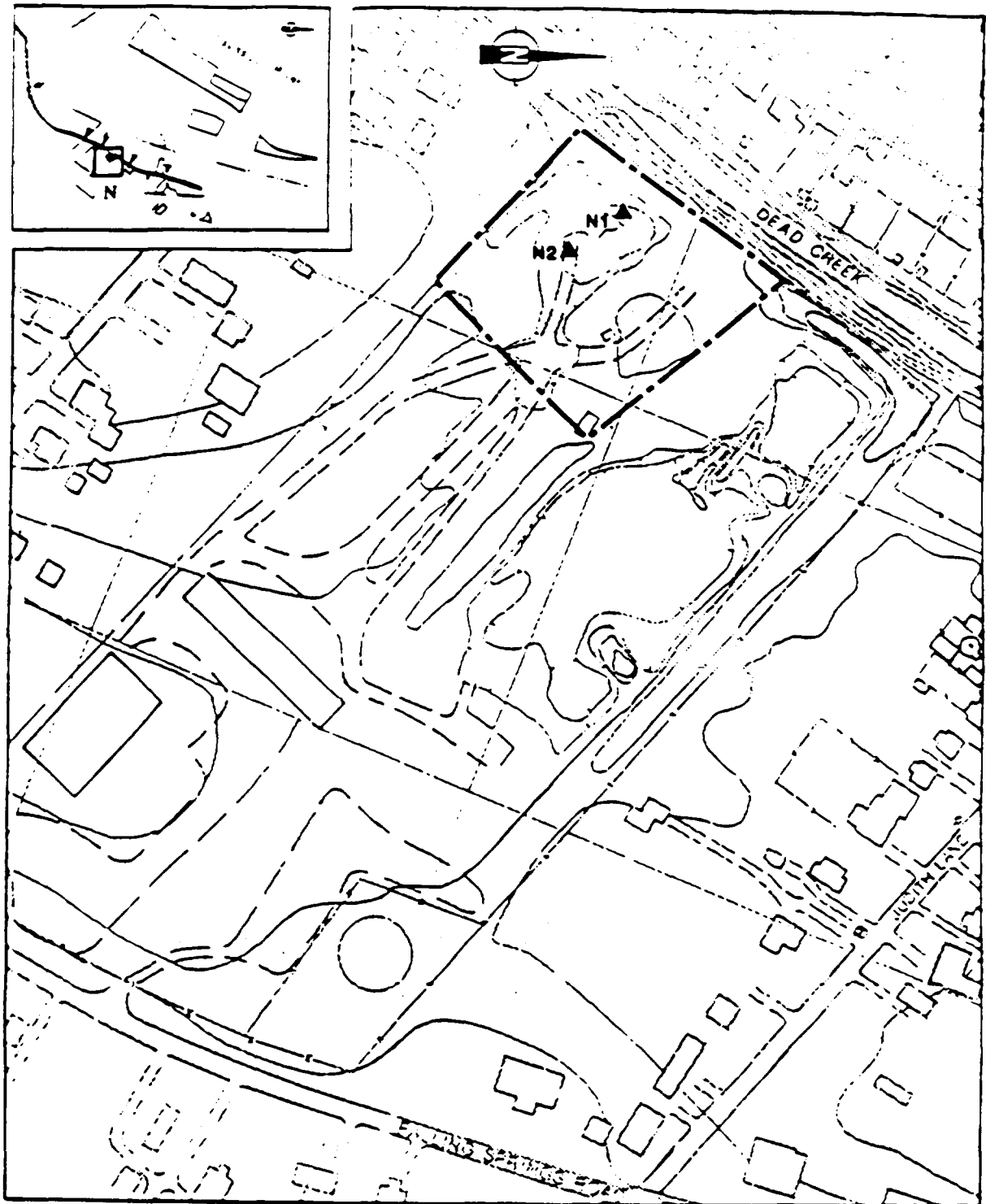
FIGURE 3-9 BORING LOCATIONS AT SITE J



SOURCE: Ecology and Environment, Inc., 1988.

SCALE
0 100 200 300 400 500 FEET

FIGURE 3-10 BORING LOCATIONS AT SITE K

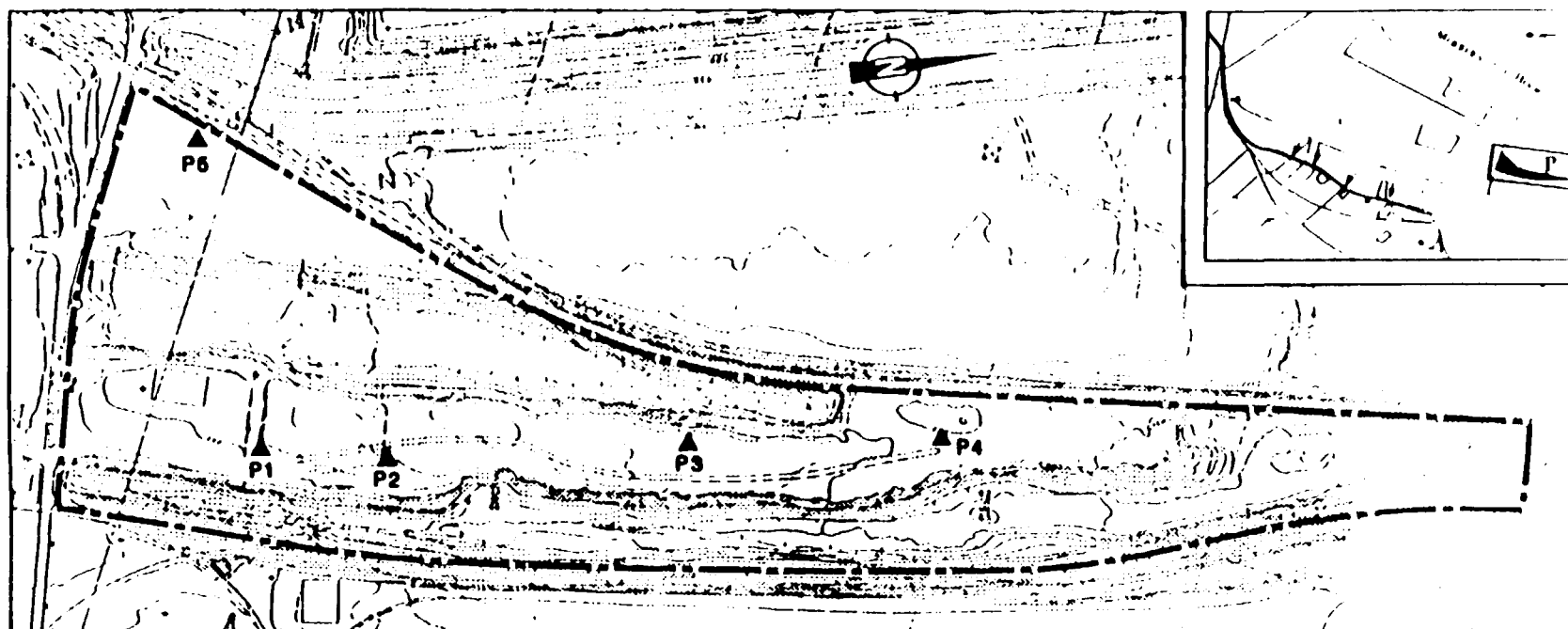


SOURCE: Ecology and Environment, Inc., 1988.



FIGURE 3-11 BORING LOCATIONS AT SITE N

Side left intentionally blank



SOURCE: Ecology and Environment, Inc., 1988.

SCALE
0 200 400 600 800 1000 FEET

FIGURE 3-12 BORING LOCATIONS AT SITE P

Table 3-4

SOIL BORING AND MONITORING WELL DEPTHS

Boring/Well Number	Date of Completion	Boring Depth (ft)	Well Depth (ft)	Elevation of Screen Bottom (MSL)	Elevation at TOIC* (MSL)
<u>Site G</u>					
G1	01/12/87	20	NA	NA	NA
G2/EE-05	01/14/87	25	23	386.06	411.36
G3/EE-11	01/26/87	25	23	384.45	409.02
G4/EE-G106	01/27/87	25	23	383.53	407.97
G5	01/27/87	20	NA	NA	NA
G6/EE-G107	02/23/87	30	28	377.55	406.67
G7	02/24/87	27.5	NA	NA	NA
G8	02/24/87	30	NA	NA	NA
G9	02/24/87	37.5	NA	NA	NA
EE-G101	02/25/87	22.5	22.5	387.34	412.35
EE-G102	02/26/87	22	21.5	386.38	409.10
EE-G103	02/26/87	23.5	21.5	386.16	408.74
EE-G104	02/25/87	24	24	383.87	408.96
<u>Site H</u>					
H1	12/18/86	50	NA	NA	NA
H2/EE-01	01/05/87	35	33	373.55	408.84
H3/EE-02	01/06/87	23	23	384.66	409.91
H4	01/07/87	50	NA	NA	NA
H5	01/08/87	27.5	NA	NA	NA
H6	01/07/87	50	NA	NA	NA
H7	01/08/87	50	NA	NA	NA
H8/EE-03	01/09/87	35	32	377.11	411.47
H9/EE-04	01/13/87	25	23	388.33	413.26
EE-G108	03/02/87	30	29	377.28	407.21
EE-G110	12/18/86	23	23	384.68	409.00
<u>Site I</u>					
I1/EE-12	01/28/87	34.5	34.5	374.14	409.16
I2	01/28/87	40	NA	NA	NA
I3	01/29/87	30	NA	NA	NA
I4/EE-13	01/29/87	27.5	27.5	381.07	409.79
I5/EE-14	01/30/87	38	38	371.39	410.95
I6	02/02/87	32.5	NA	NA	NA
I7/EE-15	02/03/87	32.5	29	376.08	406.41
I8/EE-G112	02/03/87	29	26	380.68	407.87
I9/EE-16	02/04/87	33	33	373.91	408.65
I10	02/04/87	30	NA	NA	NA
I11	02/05/87	38.5	NA	NA	NA
I12/EE-20	02/13/87	29	29	381.00	411.41

Table 3-4 (Cont.)

Boring/Well Number	Date of Completion	Boring Depth (ft)	Well Depth (ft)	Elevation of Screen Bottom (MSL)	Elevation at TOIC* (MSL)
<u>Site L</u>					
L1	12/11/86	20	NA	NA	NA
L2	12/12/86	20	NA	NA	NA
L3	12/12/86	20	NA	NA	NA
L4/EE-G109	12/16/86	25	22.5	385.27	409.71
<u>Site O</u>					
O1/EE-21	02/16/87	30	28	377.68	406.81
O2/EE-22	02/17/87	35	33	381.77	416.31
O3	02/17/87	20	NA	NA	NA
O4	02/17/87	20	NA	NA	NA
O5	02/17/87	20	NA	NA	NA
O6/EE-23	02/18/87	35	33.5	374.96	410.04
O7/EE-24	02/19/87	33	33	377.08	411.06
O8/EE-25	02/20/87	35	33	375.91	410.63
O9	02/26/87	20	NA	NA	NA
O10	02/26/87	14	NA	NA	NA
<u>Site Q</u>					
Q1/EE-06	01/19/87	33.5	33	388.22	423.51
Q2/EE-07	01/20/87	38	37.5	383.65	423.31
Q3/EE-08	01/21/87	38.5	38	382.00	421.14
Q4/EE-09	01/21/87	33	33	380.38	415.40
Q5/EE-10	01/22/87	33	32.5	384.60	419.40
Q6/EE-17	02/06/87	43	43	379.00	423.06
Q7/EE-18	02/09/87	43.5	43	375.20	419.54
Q8/EE-19	02/10/87	43	42.5	378.12	423.22
<u>Site P</u>					
P1	02/11/87	35	NA	NA	NA
P2	02/11/87	40	NA	NA	NA
P3	02/11/87	30	NA	NA	NA
P4	02/12/87	35	NA	NA	NA
P5	02/12/87	35	NA	NA	NA
<u>Site J</u>					
J1	12/17/86	20	NA	NA	NA
J2	12/17/86	25	NA	NA	NA
J3	12/17/86	25	NA	NA	NA
<u>Site K</u>					
K1	12/16/86	20	NA	NA	NA
K2	01/12/87	20	NA	NA	NA
K3	01/22/87	20	NA	NA	NA

Table 3-4 (Cont.)

Boring/Well Number	Date of Completion	Boring Depth (ft)	Well Depth (ft)	Elevation of Screen Bottom (MSL)	Elevation at TOIC* (MSL)
<u>Site N</u>					
N1	12/15/86	20	NA	NA	NA
N2	12/15/86	40	NA	NA	NA

TOIC Top of inner casing.

NA Not applicable.

Source: Ecology and Environment, Inc. 1988.

Soil borings were drilled using 3 3/4-inch ID hollow-stem augers. When heaving sands were encountered or when drilling below waste rotary wash methods, using water from the Town of Cahokia municipal system and bentonite, were also employed to complete the borings. In these situations, the hollow-stem auger served as the temporary casing through which the rotary drilling was conducted. Split-spoon samples at 2.5- or 5-foot intervals were collected at all boring locations. Samples were obtained by driving a 2-inch OD standard split-spoon sampler (ASTM D1586) with a 140-pound weight, free-falling 30 inches. The driving resistance was recorded for each 6-inch increment sampled with the split-spoon sampler. Blow counts are recorded on the boring logs in Appendix B.

After opening the split-spoon, the samples were screened with a photoionization meter (HNU) for volatile organic compounds, and readings were recorded in a logbook. A visual description of each sample was recorded on field boring logs by the project geologist. The description included the texture, density, structure, color, mineralogy, moisture content, and thickness of layers, as well as the depth to the water table.

The entire contents of each split-spoon sample was retained and placed in laboratory-cleaned 32-ounce glass jars. To facilitate future sample screening and compositing, field samples from two consecutive split-spoon intervals were stored together in each 32-ounce jar (e.g., samples from the 1- to 2.5-foot and 3.5- to 5-foot intervals were combined in one 32-ounce jar). The sample jars were suitably boxed, marked, and labeled with the date, boring number, and depth of each sample within the jar. Immediately following the completion of each boring, samples were screened for organic compounds using an OVA and the screening methodology described in Section 3.5. Following screening, depth intervals from each boring were selected for compositing and chemical analysis, based on screening results and visual observation of samples. Table 3-5 shows the locations and depths of composite samples. With the exception of samples P1-53 and P2-54, all samples were composited from depth interval samples collected from within a single boring. In sample P1-53, samples from the 0- to 10-foot depth interval in borings P-1, P-2, P-3, and P-4 were composited; in sample P2-54,

Table 3-5

SUBSURFACE SOIL SAMPLE LOCATIONS

Sample Number	Date	Sample Location (boring)	Sample Depth (ft)	Comments
<u>Site G</u>				
G1-26	01/12/87	G1	0-10	silt
G1-27	01/12/87	G1	10-20	sand
GB-29	01/14/87	—	—	soil blank
G2-30	01/14/87	G2	5-15	fill
G2-31	01/14/87	G2	5-15	duplicate of G2-30
G3-33	01/26/87	G3	10-20	clay below fill
GB-34	01/26/87	—	—	soil blank
G4-35	01/27/87	G4	5-20	clay and sand
G4-36	01/27/87	G4	5-20	duplicate of G4-35
G5-37	01/27/87	G5	5-15	waste
G6-67	02/23/87	G6	20-30	stained sand below waste
GB-68	02/24/87	—	—	soil blank
G7-69	02/24/87	G7	10-25	waste
G8-70	02/24/87	G8	10-20	waste
G9-71	02/24/87	G9	35-40	stained sand below waste
<u>Site H</u>				
H1-14	12/18/86	H1	15-25	waste
H1-15	12/18/86	H1	35-50	sand below waste
H2-16	01/05/87	H2	5-20	waste
H3-17	01/06/87	H3	10-20	silty sand
H3-18	01/06/87	H3	10-20	duplicate of H3-17
H4-19	01/06/87	H4	10-25	waste
HB-20	01/07/87	—	—	soil blank
H5-21	01/07/87	H5	0-10	fill
H6-22	01/08/87	H6	35-50	sand below waste
H7-23	01/08/87	H7	35-50	sand (background for this depth)
H8-24	01/09/87	H8	5-15	waste
H9-28	01/13/87	H9	15-25	sand (background for this depth)
<u>Site I</u>				
I1-38	01/27/87	I1	0-10	fill and waste
I2-39	01/28/87	I2	5-25	fill and waste
I3-40	01/29/87	I3	5-15	fill and clay below
I5-41	01/30/87	I5	5-27.5	waste
I5-42	01/30/87	I5	28-37.5	sand below waste
I6-43	02/02/87	I6	10-25	waste
IB-44	02/03/87	—	—	soil blank
I7-45	02/03/87	I7	3.5-12.5	fill
I7-46	02/03/87	I7	13.5-22.5	sand below fill
I7-47	02/03/87	I7	13.5-22.5	duplicate of I7-46
I9-48	02/04/87	I9	6-20	waste
I9-49	02/04/87	I9	23-30	stained sand below waste
I10-50	02/04/87	I10	15-30	stained sand
I11-51	02/05/87	I11	6-20	waste
I11-52	02/05/87	I11	26-38	sand below waste

Table 3-5 (Cont.)

Sample Number	Date	Sample Location (boring)	Sample Depth (ft)	Comments
I12-57	02/13/87	I12	3-12	sand (background for this depth)
I12-58	02/13/87	I12	18-27	sand (background for this depth)
<u>Site L</u>				
LB-01	12/12/86	--	--	soil blank
L1-02	12/12/86	L1	5-10	silt
L2-03	12/12/86	L2	5-15	fill and silt
L3-04	12/12/86	L3	5-15	fill and silt
L4-09	12/17/86	L4	10-20	silty sand
L4-10	12/17/86	L4	10-20	duplicate of L4-09
<u>Site J</u>				
J1-11	12/17/86	J1	10-20	sandy silt
J2-12	12/17/86	J2	15-25	sand
J3-13	12/17/86	J3	0-10	fill
<u>Site K</u>				
K1-08	12/16/86	K1	0-10	fill
K2-25	01/12/87	K2	0-10	fill
K3-32	01/22/87	K3	10-20	clay and sand below fill
<u>Site M</u>				
M1-05	12/15/86	M1	0-10	silt
M2-06	12/15/86	M2	5-15	silt & sand below fill
MB-07	12/16/86	--	--	soil blank
<u>Site P</u>				
P1-53	02/11/87	P1, P2, P3, P4	0-10	fill (composited across borings)
P2-54	02/11/87	P1, P2, P3, P4	25-35	sand below fill (composited across borings)
P5-55	02/12/87	P5	10-25	fill
P5-56	02/12/87	P5	10-25	duplicate of P5-55
<u>Site O</u>				
O1-59	02/16/87	O1	15-25	sand (background for this depth)
O2-60	02/17/87	O2	20-30	sand
O3-61	02/17/87	O3	10-20	silty sand
O4-62	02/17/87	O4	0-10	sludge and sand
O5-63	02/17/87	O5	8-20	sand
O5-64	02/17/87	O5	8-20	duplicate of O5-63
OB-65	02/18/87	--	--	soil blank
O6-66	02/18/87	O6	15-25	sand
O9-72	02/26/87	O9	0-10	fill
O9-73	02/26/87	O9	15-20	stained sand
O10-74	02/26/87	O10	5-10	sludge
O10-75	02/26/87	O10	10-15	stained sand

Source: Ecology and Environment, Inc. 1988.

samples from the 25- to 35-foot interval were composited from the same four borings. This was done because of the limited number of samples scheduled for Site P and the desire to have chemical data for a wider portion of the site.

Depth interval samples were composited in the following manner:

- The entire portion of each depth interval to be composited was thoroughly mixed in a clean stainless steel bowl using a stainless steel tablespoon.
- Material was chopped, mixed, and stirred until it was reasonably homogenous.
- A stainless steel tablespoon was used to transfer the material to the appropriate sample containers. A clean stainless steel tablespoon was dedicated for materials for each composite.
- Sample jars were sealed, labeled, and packaged for shipment as specified in the project QAPP.

QA/QC samples included one duplicate sample for every 10 field samples and a blank soil sample for each shipment to the laboratory. Blank soil samples were collected from soils taken from an undisturbed area east of Area 1 sites. All samples were shipped to the ASC, and analyzed for the parameters listed in Table 3-2.

3.6.2 Monitoring Well Construction

All monitoring wells were constructed from 2-inch ID threaded, flush-jointed 304 stainless steel well casing. Casings terminated in a continuous wire-wound well screen with a slot size of 0.010 inches. Screens were also constructed from 304 stainless steel. A 5-foot screen length was used at each well. A stainless steel plug was welded to the bottom of each screen. Stainless steel was chosen because of its general inertness to chemical attack and poor sorptive properties in the presence of chlorinated organic compounds.

In most cases, the well screens were surrounded by a natural sand pack that collapsed around the screen after augers were raised or drilling fluid was removed. The depth to the sand pack was checked with a weighted tape to ensure that the annular space around the screen was properly filled. When formation collapse did not occur or did not cover the screen, a clean silica sand was placed in the annulus to complete the sand pack. Sand packs were extended to at least 2 feet above the top of the screen. A minimum 2-foot-thick bentonite pellet seal was then placed around the well casings above the sand pack. The remainder of the annulus was then tremie-grouted to the surface with a bentonite/cement slurry.

To complete the well installations, 4-inch ID round, locking steel protective casings were placed around the well casings and embedded in the grout. Concrete plugs were placed around the protective casings at the ground surface to prevent storm runoff from entering the borehole. Specific well construction details for each well are presented in the boring logs in Appendix B. After installation, all wells were not disturbed for a minimum of 3 days before being developed. This period allowed sufficient time for the bentonite well seal to swell and the grout to set before development began.

3.6.3 Monitoring Well Development

An air-lift method was used to develop each well. In this method, a 1/4-inch ID air line was taped to the outside of 3/4-inch ID flush-jointed PVC pipe of sufficient length to reach the bottom of the wells. The submerged end of the air line was bent and inserted into the open end of the PVC pipe so as to direct the flow of air up into the pipe and not into the formation surrounding the screen. As pressurized Grade D air was applied to the air line, water was lifted inside the PVC pipe and discharged by way of a T-fitting at the surface to a 55-gallon drum. Water was pumped from the wells until a minimum of 15 well volumes were removed or until the discharged water was relatively clear and free of fine sand or silt-sized particles. All development equipment, including the PVC pipe and air line, was steam-cleaned between each well to prevent cross-contamination.

3.6.4 Decontamination

Prior to the mobilization of the drill rig on each site, the rig and all associated drilling equipment were thoroughly cleaned with a hot water pressure wash system. All tools and equipment were steam-cleaned between borings to prevent cross-contamination. Monitoring well casings and screens were also steam-cleaned prior to installation. During drilling, the split-spoon sampler was cleaned between uses by scrubbing with brushes in a trisodium phosphate solution followed by rinses of deionized water, dilute acetone, dilute hexane, dilute acetone, and a final deionized water rinse. Spent decontamination fluids were containerized in a 55-gallon drum.

3.6.5 Aquifer Measurements

3.6.5.1 Water Level Measurements

Water levels were measured in newly installed monitoring wells on March 26, May 12, and October 1, 1987. On October 1, a select number of Monsanto Chemical Co. wells and piezometers were also measured at Site R. A chalked, graduated stainless steel tape was used for each measurement. Readings were accurate to 0.01 foot. Measurements were also recorded on March 26 and October 1 for pool elevations in the two ponds which constitute CS-A at Site I. Water levels in the northern half of CS-B were insufficient to measure on all three measurement dates. Daily readings of the Mississippi River stage were also obtained for the period January 1 to November 1, 1987, from the COE Market Street gauge.

All monitoring well measurements were recorded from the tops of the inner casings (TOIC) inside the protective casings. The measuring tape was cleaned between each well with deionized water to prevent cross-contamination. All water levels were recorded within a 24-hour period on each measurement date.

Water level data were converted to elevations above mean sea level (MSL) based on a survey of wells conducted by E & E on March 4 and 5, 1987. All elevations were referenced to benchmarks established by Surdex Corporation during the topographic mapping of DCP sites.

Water level data are reported in Section 4.1.3.3.

3.6.5.2 Hydraulic Conductivity Tests

Slug tests were performed on May 11, 12, and 13, 1987, to determine the in-situ hydraulic conductivity of aquifer materials at 15 representative monitoring wells. These included EE-G101 and EE-G102 at Site G; EE-03, EE-04, and EE-G110 at Site H; EE-13, EE-15, and EE-G112 at Site I; EE-21, EE-24, and EE-25 at Site O; and EE-06, EE-08, EE-09, and EE-17 at Site Q.

In this test, a water tight cylinder (slug), consisting of a 1-inch ID, 5-foot-long PVC pipe filled with silica sand and attached to a stainless steel cable, was inserted into the well and positioned below the water table. By inserting the slug, a known volume of water was displaced, thereby raising the water level in the well. After the water level had returned and stabilized at its initial static level, the slug was suddenly removed from the well. By removing this known volume, the water level was depressed below the static level and the test was allowed to begin. The water level was then measured at a sequence of 0.2-, 1-, and 5-second intervals until it returned to the static level. An Enviro-Labs DL-120 pressure transducer and field printer were used to measure and record changes in head versus elapsed time.

Field test data was analyzed using the Hvorslev (1951) method. In this analysis, it is assumed that the aquifer is unconfined, the well is of small diameter, and the length of the screen is small compared with the length of the well. A regression technique was used to determine a best fit approximation for the field test data. The equation for the best fit line was then used to determine the basic time lag, which in turn was used to compute the hydraulic conductivity (K).

Because slug tests yield conductivity values for only a small portion of the aquifer immediately around the well screen, a large number of tests were conducted within the study area in order to estimate the hydraulic conductivity of the aquifer (in this case the upper portion) as a whole.

Results of the slug tests are reported in Section 4.1.3.3.

3.6.6 Infiltration Testing

A Soil Test TM Model 422-500, double ring-infiltrometer was used to determine the infiltration rate of surficial soils at sites G, H, O, and

Q. Two locations in the fill material at Site H were tested on June 20, 1987. On July 14, 1987, one test was conducted on the clayey cover material of lagoon #3 at Site O. At Site G, two tests were conducted on July 20, 1987. The first test location was in an undisturbed portion of the site near soil boring G1. The second test was located in a fill area in the vicinity of boring G5. One test was also conducted at Site Q on July 20, 1987, near boring Q7/EE-18.

Test procedures were in accordance with ASTM standard D3385-75. In this method, two open cylinders (12- and 24-inch diameter), one inside the other, are driven into the ground and partially filled with water which is then maintained at a constant level. The volume of water added to maintain the water level is the measure of the volume of water that infiltrates the soil. The volume infiltrated during timed intervals is converted to an infiltration velocity expressed in inches per hour. The maximum infiltration velocity is equivalent to the infiltration rate.

The ASTM standard indicates that many factors affect the infiltration rate, e.g., the soil structure, the condition of surface soils, soil moisture content, the chemical and physical nature of the soil and of the applied water, the head of applied water, and the temperature of the water. The ASTM also indicates that rates determined by ponding of large areas are considered the most reliable method of determining infiltration rates, but that, because of the high cost of this method, the infiltrometer-ring method is more feasible economically. Because of the number of aforementioned variables and the fact that tests made at the same site are not likely to give identical results, the rates determined by this method were used for comparative purposes only.

The results and a discussion of the infiltration testing are presented in Section 4.1.4.

3.7 GROUNDWATER SAMPLING

A single round of groundwater samples was collected from all DCP monitoring wells during the weeks of March 16 and March 23, 1987. In addition to the monitoring wells, four residential wells and one active industrial well (Clayton Chemical Company) were sampled. The purpose of the groundwater sampling was to provide site-specific and area-wide groundwater quality data, identify contaminants present at the DCP

sites, and determine the extent and location of contaminated plumes. Fifty-six groundwater samples, including ten field QC samples, were collected. Sampling procedures, record-keeping requirements, QA/QC, and subsequent chemical analysis were governed by the QAPP and sampling plan developed for the project. Table 3-6 lists the locations of all groundwater samples collected. Sample locations for the Area 1 and Area 2 sites are shown in Figures 3-13 and 3-14, respectively. Private well sample locations are shown in Figure 3-15.

During the groundwater sampling, sample bottles from three monitoring wells (EE-G102, EE-21, and EE-23) were broken prior to analysis. Well EE-21 is the background well for Site 0. QC guidelines for HRS scoring stipulate that background data must be collected for each media sampled, in order to provide a comparison between "natural" conditions and conditions resulting from site activities. Because the background sample for Site 0 was lost, resampling of all wells on the site was necessary. A replacement sample for well EE-G102 near Dead Creek was also collected. All replacement samples were collected on July 14, 1987.

All groundwater samples were submitted to the ASC for analysis of HSL organics as well as metals and cyanide (see Table 3-2). Temperature, pH, and specific conductivity measurements were also recorded in the field for each sample.

Groundwater sample results are presented and discussed in Section 4.2.5 of this report.

3.7.1 Sampling Equipment

Dedicated 1 1/4-inch ID bottom-filling stainless steel bailers and stainless steel cables were used to purge monitoring wells and collect groundwater samples. During well purging and sampling, bailer cables were directed into plastic-lined wash tubs in order to prevent contact with the ground surface. Samples from private wells, with one exception, were collected from outside taps. The exception (GW-55) was collected from a residential well constructed of 1-inch ID steel casing with a fixed elbow at the surface. This well was sampled using a Masterflex sampling pump with Tygon tubing.

Table 3-6

GROUNDWATER SAMPLE LOCATIONS

Sample Number	Date Sampled	Sample Location	Comments
GW-01	3-16-87	Site Q, Well EE-06	
GW-02	3-16-87	Site Q, Well EE-07	
GW-03	3-16-87	Site Q, Well EE-09	
GW-04	3-16-87	Site Q, Well EE-10	
GW-05	3-16-87	Site Q, Well EE-17	Background well-Site Q
GW-06	3-16-87	Site Q, Well EE-08	
GW-07	3-16-87	Site Q, Well EE-19	
GW-08	3-16-87	Site Q, Well EE-19	Duplicate of GW-07
GW-09	3-16-87	Site Q, Well EE-18	
GW-10	3-17-87	Site H, Well EE-01	
GW-11	3-17-87	Site H, Well EE-02	
GW-12	3-17-87	Site H, Well EE-03	
GW-13	3-17-87	Site H, Well EE-04	Background well-Site H
GW-14	3-17-87	Site G, Well EE-G101	
GW-15	3-17-87	CS-B, Well EE-G103	
GW-16	3-17-87	CS-B, Well EE-G104	
GW-17	3-17-87	Blank water	Deionised water blank
GW-18	3-18-87	Site L, Well EE-G108	Background well-Site L
GW-19	3-18-87	Site G, Well EE-G107	
GW-20	3-18-87	Site G, Well EE-G107	Duplicate of GW-19
GW-21	3-18-87	Site G, Well EE-05	
GW-22	3-18-87	Blank water	Deionised water blank
GW-23	3-23-87	Site I, Well EE-13	
GW-24	3-23-87	Site I, Well EE-12	
GW-25	3-23-87	Site I, Well EE-G112	
GW-26	3-23-87	Site I, Well EE-14	
GW-27	3-23-87	Site I, Well EE-15	
GW-28	3-23-87	Site I, Well EE-16	
GW-29	3-23-87	Site I, Well EE-12	Duplicate of GW-24
GW-30	3-23-87	Blank water	Deionised water blank
GW-31	3-23-87	Site I, Well EE-20	Background well-Site I
GW-32	3-24-87	Site G, Well EE-11	
GW-33	3-24-87	Site G, Well EE-G106	
GW-34	3-24-87	Site G, Well EE-G102	
GW-35	3-24-87	Blank water	Deionised water blank
GW-36	3-24-87	Site H, Well EE-G110	
GW-37	3-24-87	Site L, Well EE-G109	
GW-38	3-24-87	Site O, Well EE-21	Background well-Site O
GW-39	3-24-87	Site O, Well EE-22	
GW-40	3-24-87	Site O, Well EE-23	
GW-41	3-24-87	Site O, Well EE-24	
GW-42	3-24-87	Site O, Well EE-24	Duplicate of GW-41
GW-43	3-24-87	Site O, Well EE-25	
GW-44	3-25-87	Site R, Well P-1	
GW-45	3-25-87	Site R, Well B-28A	

Table 3-6 (Cont.)

Sample Number	Date Sampled	Sample Location	Comments
GW-46	3-25-87	Site R, Well P-7	
GW-47	3-25-87	Site R, Well B-26A	
GW-48	3-25-87	Site R, Well B-26A	Duplicate of GW-47
GW-49	3-25-87	Site R, Well B-25A	
GW-50	3-25-87	Site R, Well P-11	
GW-51	3-25-87	Blank water	Deionized water blank
GW-52	3-26-87	Wright residence	100 Judith Lane
GW-53	3-26-87	Settles residence	102 Judith Lane
GW-54	3-26-87	Schmidt residence	104 Judith Lane
GW-55	3-26-87	McDonald residence	109 Judith Lane
GW-56	3-26-87	Clayton Chemical well	
GW-38A*	7-14-87	Site O, Well EE-21	
GW-39A*	7-14-87	Site O, Well EE-22	
GW-40A*	7-14-87	Site O, Well EE-23	
GW-41A*	7-14-87	Site O, Well EE-24	
GW-43A*	7-14-87	Site O, Well EE-25	
GW-57	7-14-87	Blank water	Deionized water blank
GW-34A*	7-14-87	Site G, Well EE-G102	

* Replacement samples. Original samples GW-38, GW-40, and GW-34 were not able to be analyzed because sample bottles were broken. All wells at Site O were resampled, as was well EE-G102.

Source: Ecology and Environment, Inc. 1988.

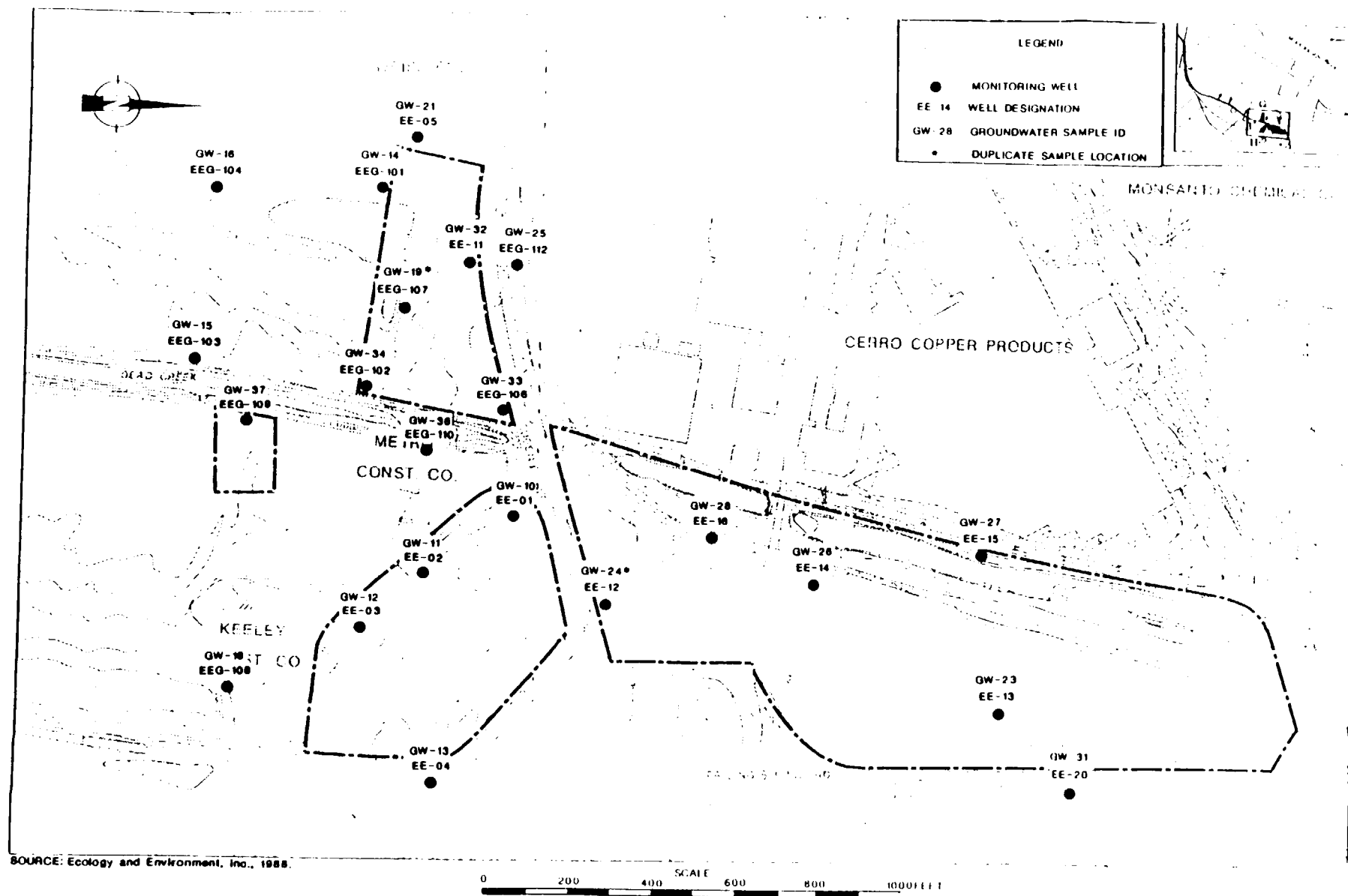


FIGURE 3-13 GROUNDWATER SAMPLING LOCATION
AT AREA 1 SITE

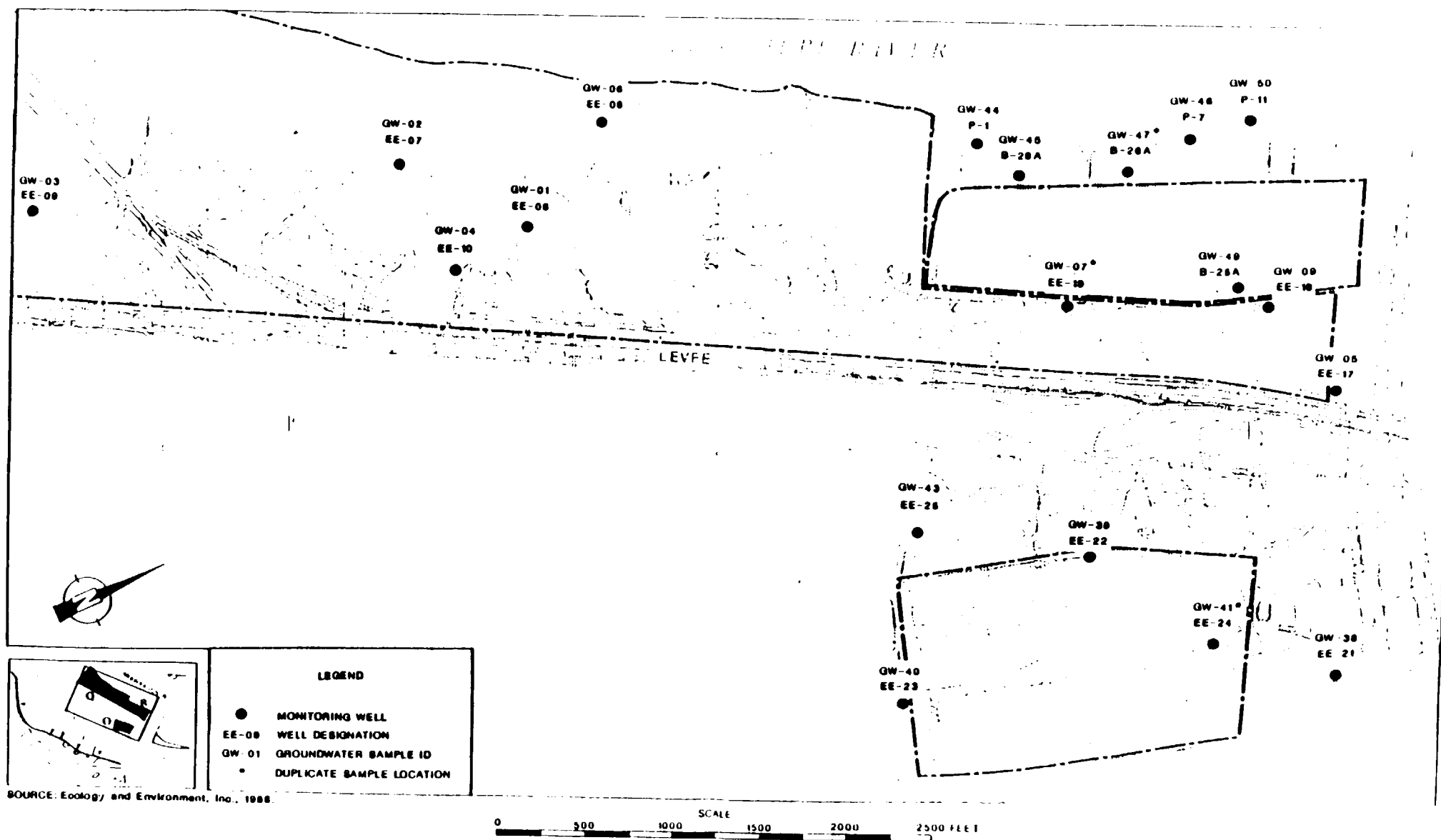
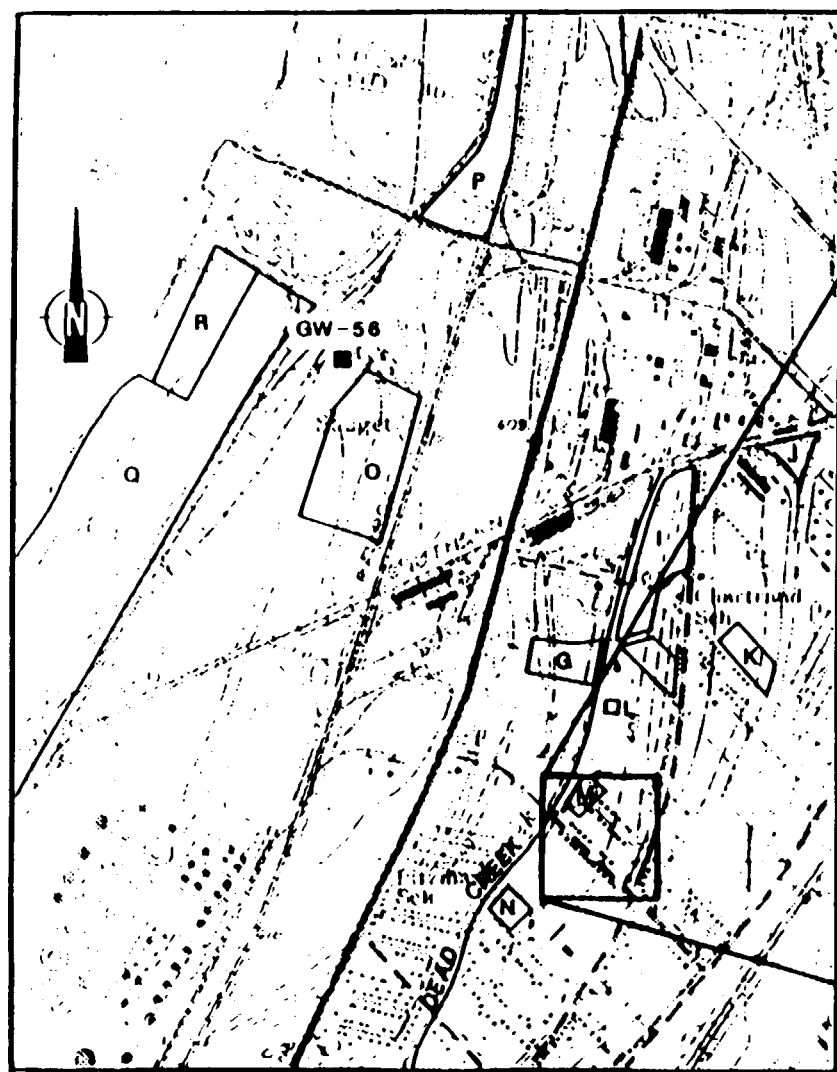
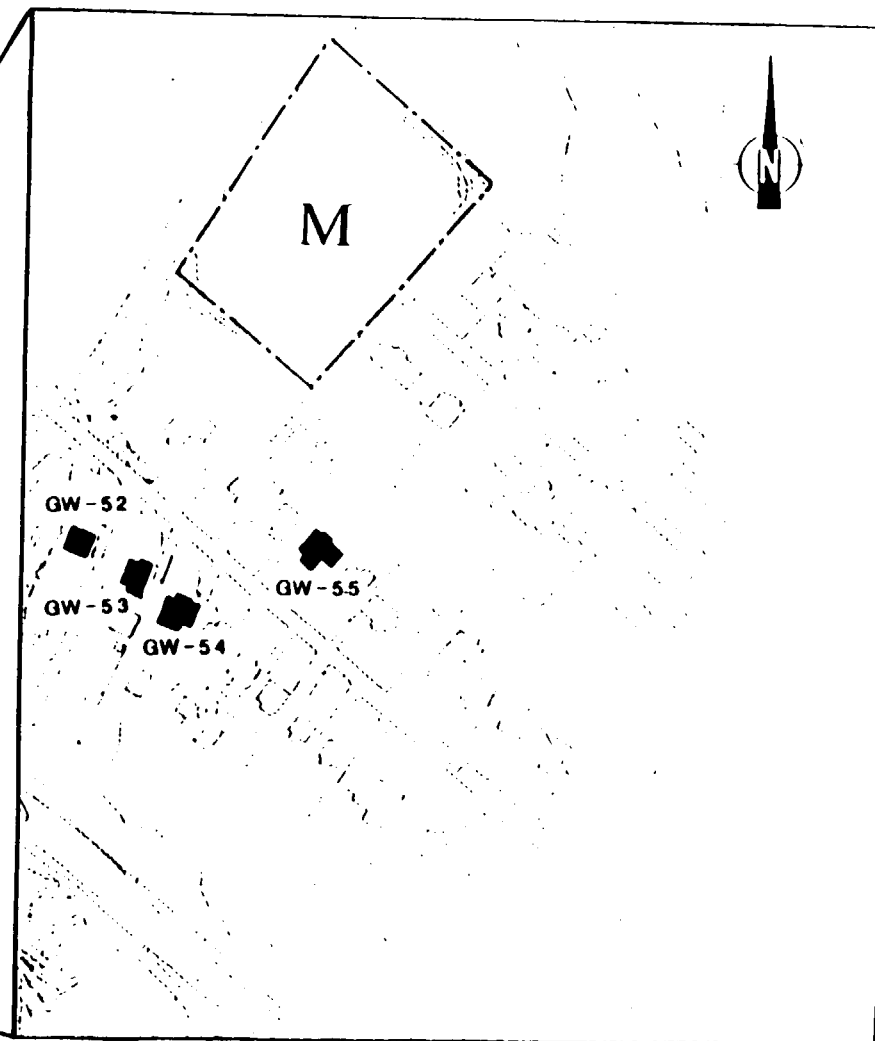


FIGURE 3-14 GROUNDWATER SAMPLING
LOCATIONS AT AREA 2 SITE 1



SOURCE: Ecology and Environment, Inc., 1988.

SCALE
1000 0 1000 2000 3000 4000 5000 FEET



SCALE
100 0 100 200 300 400 500 FEET

FIGURE 3-15 PRIVATE WELL SAMPLING LOCATIONS

3.7.2 Well Evacuation

Prior to collecting groundwater samples, the static water level in each monitoring well was measured to determine the volume of water in each well. After calculating the volume of water stored in each casing, wells were purged using stainless steel bailers. A minimum of three well volumes was purged from each monitoring well. Samples were collected immediately after purging at each well.

Residential wells were purged by allowing outside taps to flow for approximately 5 minutes prior to sample collection. The well sampled with the Masterflex pump was also purged for approximately 5 minutes. Because the well at Clayton Chemical is pumped on a regular basis, the tap was allowed to flow for approximately 3 minutes in order to acclimate the tap line plumbing.

3.7.3 Decontamination

Stainless steel bailers purchased for the groundwater sampling were thoroughly cleaned off-site prior to use to remove any contamination resulting from the manufacturing process. Bailers were cleaned using the decontamination procedure described in Section 3.4 of this report. The procedure includes scrubbing in a trisodium phosphate solution, a triple solvent rinse, and two deionized water rinses. After cleaning and drying, bailers were wrapped in aluminum foil for transport to the field, and kept wrapped until their use. Replacement samples were collected using the same bailers as used initially for each well. The same decontamination procedure was used prior to collecting the replacement samples.

3.7.4 Sample Filtering and Preservation

Groundwater samples collected for metals analysis were filtered in the field prior to submittal to the laboratory. The filtering procedure consisted of using a Masterflex pump to draw a sample into a filter assembly containing Teflon screens and a 0.45-micron filter. Samples were pumped through this assembly into clean 1-liter plastic sample bottles. After filtering, samples were preserved with nitric acid and iced in the shipping container.

Whenever possible, visually clean samples and blanks were filtered before oily or dirty samples. Between samples, deionized water was run through the filter assembly and tubing in order to avoid cross-contamination. If exceptionally dirty or oily samples were encountered, filter tubing was replaced prior to filtering another sample.

As stated above, samples analyzed for metals were preserved with nitric acid. Samples submitted for cyanide analysis were preserved with sodium hydroxide. All samples analyzed for organic parameters were cooled with ice prior to shipment, as were the samples for metals and cyanide analysis. Sample bottles were labeled and placed in plastic bags to avoid contamination from the vermiculite used as packing material. Custody seals were placed on the lids of each sample bottle and on the lids of the ice chests used for shipment.

QA/QC for the sampling were governed by the project QAPP. Chain-of-custody and record-keeping procedures as described in the QAPP were also followed.

The analytical results for groundwater samples are presented and discussed in Section 4.2.5 of this report.

3.8 AIR SAMPLING

Air sampling was conducted at two DCP aggregate site areas (Area 1 and Area 2) in order to increase the possibility of qualifying sites for inclusion on the USEPA NPL. Sampling procedures, QA/QC, and subsequent chemical analysis were governed by an addendum to the project QAPP, submitted to IEPA in March 1987. Air samples were collected during the weeks of July 13 and July 20, 1987.

3.8.1 Monitoring Strategy and Design

Previous investigations in the DCP area had indicated the presence of a wide variety of contaminants in several media. For this reason, an air sampling strategy was developed to address a wide range of chemicals rather than focusing on a single class, or group, of compounds. The sampling program was also designed to address both volatilization of contaminants and contaminants bound to airborne particulates. USEPA QC requirements for scoring an air release using the HRS model are very stringent. A detailed sampling approach, resulting in quantified data,

was necessary to meet the requirements. The DCP air sampling strategy was designed to satisfy all QC requirements for HRS scoring and provide source identification and quantified data concerning the nature and extent of air contamination at the sites sampled.

As described in the QAPP addendum, air samples were collected at "worst-case" sites in order to maximize the potential for detecting airborne contaminants. Area 1 sites where air samples were collected included Dead Creek (CS-B) and Site G. Area 2 sites sampled included Sites Q and R. The QAPP addendum also specified additional site-specific sampling, if necessary, to meet HRS requirements. The HRS model is currently undergoing revision, and because its final form is uncertain, additional sampling would have been of little value, and therefore was not conducted.

The air sampling investigation consisted of recording meteorological data, such as wind speed and direction, and collecting air samples with both modified high-volume samplers and lower-volume personal sampling pumps. The high-volume sampler was equipped with a particulate filter, and a glass sampling cartridge loaded with polyurethane foam (PUF) and Florisil granular sorbents assembled in series. Air samples were also collected using lower flow rates on activated charcoal and PUF sample tubes with the personal sampling pumps. For each area sampled, high-volume stations were located at one upwind background location, and four downwind locations. One duplicate (collocated) station was also placed in a downwind location. Low-flow pumps were run at five locations corresponding to the high-volume stations.

A total of 132 air samples, including 40 field QC samples, were collected during the investigation. At each high volume station, samples were collected at 12-hour intervals over a 2-day period. Three samples were collected per station, resulting in 30 air samples plus six duplicates for each area sampled (Site G/CS-B and Sites Q/R). In addition, six field blanks were submitted for each area. At each low-volume station, samples were collected at 8-hour intervals over a 2-day period. Two samples were collected per station, resulting in 16 air samples plus four duplicates for each area sampled. Four field blanks were also submitted for the low-volume sampling assembly for each area.

The number of samples described here represents individual sample analyses for each sample medium employed. For reporting purposes, each sample location was assigned a numerical designation, which represents all sample media and analyses for each location. Sample locations for Site G/CS-B and Sites Q/R are shown in Figures 3-16 and 3-17, respectively.

3.8.2 High-Volume Sampling Assembly

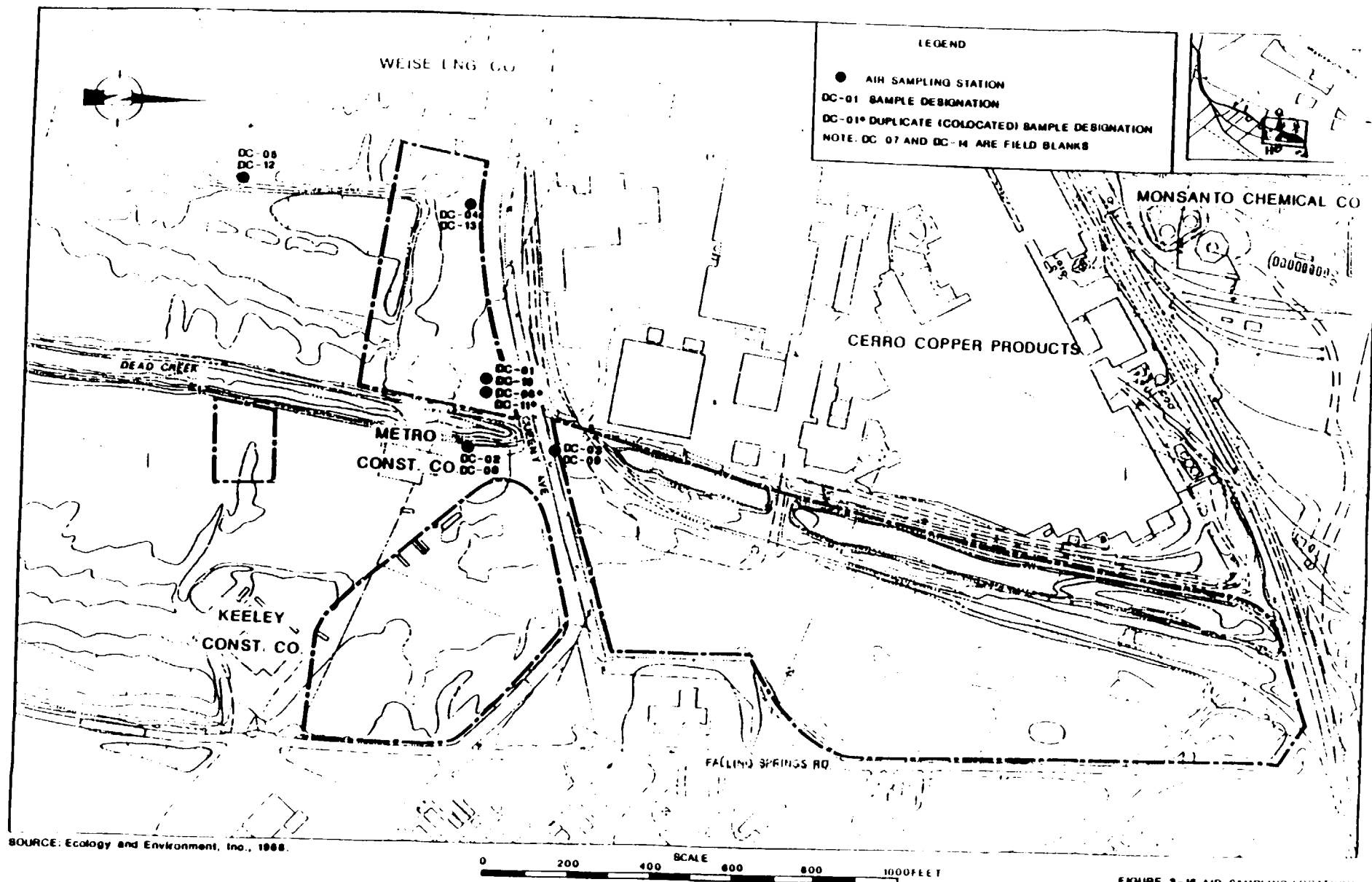
High-volume air samples were collected using a General Metals Works (GMW) Model PS-1 air sampler. The PS-1 sampler contained a special sampling assembly which held a 4-inch diameter glass fiber filter at the inlet and a glass sampling cartridge in its lower cannister. The sampling cartridge was loaded with PR grade Florisil sorbent, sandwiched between two PUF plugs.

3.8.2.1 PUF/Florisil Cartridges

Loaded sampling cartridges were prepared and precleaned at the ASC prior to shipment to the field. Loaded cartridges consisted of two PUF plugs, 50 mm and 25 mm in length, and each 65 mm in diameter, sandwiched around 25 mL of 16/30 mesh, PR grade Florisil sorbent. Prior to loading the cartridges, the PUF plugs were cleaned by extracting with acetone for 12 hours in a Soxhlet extractor, and drying under vacuum at room temperature. Assembled cartridges were rinsed with hexane, acetone, and water and dried in a desiccator. Prior to shipment, two assembled cartridges were re-extracted, and the extracts were analyzed as laboratory blanks to ensure the adequacy of the cleanup procedure. Cartridges were wrapped in aluminum foil and placed in individual, padded samples jars for shipment.

3.8.2.2 Particulate Fibers

Whatman QMA glass fiber filters (4-inch diameter) were used to collect particulate samples. As a QC procedure, three filters were digested for metals analysis and three filters were extracted for PCB, pesticide, and semivolatile analysis prior to transport to the field. Filters were dried in a desiccator for 24 hours, weighed to 0.0001-gram accuracy, and placed in individual labeled petri dishes for transport.



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 3-18 AIR SAMPLING LOCATIONS
AT SITE G/CS B

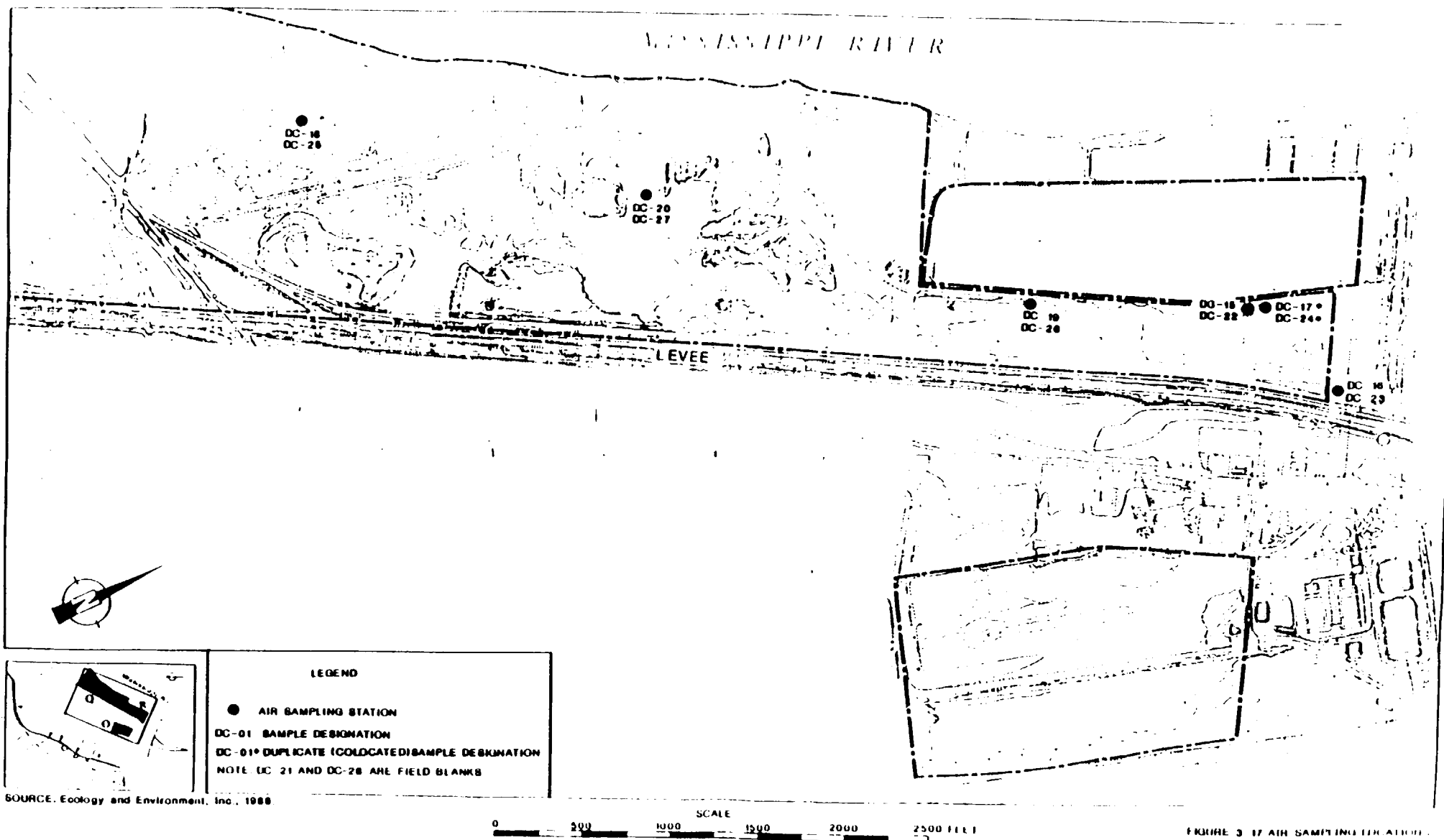


FIGURE 3-17 AIR SAMPLING LOCATIONS
AT BITES Q AND H

3.8.2.3 Sampling Procedure

Prior to initiating sampling, the GMW PS-1 samplers were calibrated according to the procedures described in the QAPP addendum. An orifice calibration unit, designed specifically for the PS-1 sampler, was employed for calibration. The samplers were elevated in order to place the sampling head at approximately 5 feet above ground surface, and plastic sheeting was placed on the ground in the immediate vicinity of the samplers to avoid dust generation. Power was supplied to the units by gas-powered generators, which were placed downwind of the samplers to prevent sample contamination from the generators.

High-volume samples were collected for a 12-hour period at a flow rate of approximately 8 cubic feet per minute (cfm). Actual flow rates were calculated following the sampling period by incorporating meteorological data, the volumetric flow derived from calibration of the units, and elapsed sampling times. Calibration data and flow calculations are included in Appendix C of this report.

Motor failure occurred on the final day of sampling at Sites Q and R at sample location DC-27. The motor was inspected in the field for typical malfunctions such as brush wear, but it could not be repaired. Because the motor failure occurred after only 2 hours of elapsed sampling time, the sample was not submitted for analysis.

Specific operating procedures were followed as delineated in the QAPP addendum. The PS-1 samplers and generators were monitored at 1-hour intervals through the sampling period, and maintenance was performed as needed. Gloved hands and forceps were used to install and remove sample cartridges and filters. Meteorological data were obtained from the Bi-State Parks Airport, which is located less than 1 mile from the areas sampled. Meteorological data were recorded at four intervals during the sampling period, as were Magnehelic gauge (theoretical flow) readings.

A field blank, including a filter and a loaded cartridge, was shipped to the ASC for each day of sampling. Field blanks were exposed to conditions at downwind locations without having air drawn through the media. All record-keeping, packaging, and custody procedures were also followed as described in the QAPP addendum.

3.8.3 Low-Volume Sampling Assembly

Low volume air samples were collected using Gilian Instrument Corporation Model HFS 113UT sampling pumps and sorbent sampling tubes. Both charcoal and PUF sorbent tubes were used as sample collection media. Specific flow rates for each sample tube were achieved by using a flow controller manifold.

3.8.3.1 Charcoal Sorbent Tubes

Supelco, Inc. (catalog number ORBO-32) charcoal sorbent tubes were used for the investigation. These consisted of 150 mg of activated coconut charcoal, 20/40 mesh, arranged in front and back sections separated by small PUF plugs. The charcoal tubes were sealed by the manufacturer, and required no cleanup or preparation prior to use.

3.8.3.2 PUF Tubes

PUF sorbent tubes were prepared and cleaned at the ASC. PUF was initially cleaned using the procedure described in Section 3.8.2.1. PUF plugs were then cut into 7.5-cm lengths with a diameter of approximately 22 mm, and loaded into 20 mm ID by 20 cm borosilicate glass tubes drawn down to a 7-mm open connection for attachment to the manifolds. PUF tubes were solvent-rinsed and dried in a desiccator, and then wrapped in aluminum foil for transport to the field.

3.8.3.3 Sampling Procedure

Low-volume sampling pumps and manifold assemblies were calibrated prior to sample collection using a standard rotometer (BUC calibrator). Sampling tubes were placed approximately 5.5 feet above the ground surface adjacent to high-volume samplers. For each area sampled (Site G/CS-B and Sites Q/R), low-volume assemblies were located in one upwind background location and four downwind locations corresponding to high-volume stations. Charcoal and PUF sorbent tubes were placed in the flow control manifold in a vertical position with the sample inlets facing downward.

Samples were collected for an 8-hour period, with manifold inlets set to flow rates of approximately 1 L/min for the PUF tubes, and approximately 100 mL/min for the charcoal tubes. Sample pumps were moni-

tored at 1-hour intervals over the course of sampling.

At the end of the sampling period, the sampling assemblies were recalibrated to obtain final flow rates. Average flow rates and total sample volumes were calculated using initial and final flow rates from the calibrations. Sample tubes were capped immediately after the final calibration, and placed in individual, labeled wrappings. Field blanks were submitted to the ASC for each day of sampling. All sample handling, packaging, and custody procedures were followed as specified in the QAPP addendum.

3.8.4 Sample Parameters

All air samples were submitted to the ASC for analysis. Particulate filters from the high-volume assembly were quartered, with two diagonally opposite quarters analyzed for metals, and the remaining portions analyzed for PCBs, pesticides, and semivolatile organic compounds (see Table 3-2). High-volume sampling cartridges (PUF/Florisol) were analyzed for PCBs, pesticides, and semivolatiles. The PUF sorbent tubes from the low-volume assembly were analyzed for semivolatile compounds, and the charcoal sorbent tubes were analyzed for volatile organic compounds.

Analytical data were received from the ASC with the results reported in ug per sample medium (e.g., PUF cartridge, filter, etc.). These results were subsequently converted to a standard unit of ug/m^3 using final flow volume calculations for the high- and low-volume sampling assemblies. All flow data were corrected to standard temperature (77°F) and pressure (29.92 inches Hg). Flow volume calculations and calibration data are included in Appendix C. A breakdown of air samples and analyses is presented in Table 3-7.

The extraction procedure employed for the semivolatile analysis of high-volume PUF cartridges led to the formation of an alcohol which caused column decomposition. Due to this problem, semivolatile analysis of the PUF cartridges was halted after samples DC-01 through DC-07.

Analytical procedures were governed by the addendum to the project QAPP. Blanks, replicates, and matrix spike samples were analyzed as specified in the QAPP addendum.

Sample results are presented and discussed in Section 4.2.6 of this report.

Table 3-7

AIR SAMPLE LOCATIONS, MEDIA, SAMPLE NUMBERS, AND ANALYSES

Area	Collection Medium	Samples**	Analysis
Site G/Dead Creek	Glass Fiber Filter (1/2)*	14	Metals
	Glass Fiber Filter (1/2)*	14	PCBs, Pesticides, Semivolatiles
	PUP/Florisil	14	PCBs, Pesticides, Semivolatiles
	Sorbent Tube - PUF	12	Semivolatiles
	Sorbent Tube - Charcoal	12	Volatiles
Site Q/Site R	Glass Fiber Filter (1/2)*	14	Metals
	Glass Fiber Filter (1/2)*	14	PCBs, Pesticides, Semivolatiles
	PUP/Florisil	14	PCBs, Pesticides, Semivolatiles
	Sorbent Tube - PUF	12	Semivolatiles
	Sorbent Tube - Charcoal	12	Volatiles

* Filters were cut into quarters, with diagonally opposite quarters being combined for analysis.

** The number of samples listed includes two blanks and two duplicates for each collection medium listed.

Source: Ecology and Environment, Inc. 1988.

4. PHYSICAL AND CHEMICAL INVESTIGATION RESULTS AND DISCUSSION

4.1 PHYSICAL RESULTS AND DISCUSSION

This section presents the results of the geophysical and hydrogeologic investigations conducted by E & E at the DCP sites. These investigations were conducted to meet the site characterization objectives outlined in Section 1 of this report. Requirements for site characterization included an evaluation of site-specific geologic conditions, an assessment of the groundwater regime on a site-specific and area-wide basis, and the delineation of contaminant sources and their effects on the local environment.

The evaluation of the area is based on data obtained from the electromagnetic (EM) and magnetometry surveys, subsurface drilling and sampling, monitoring well installation, and aquifer measurement tasks described in Section 3. Investigation-derived data were supplemented with published reports from ISWS, ISGS, and IEPA.

4.1.1 Geophysical Surveys

A geophysical investigation, including flux-gate gradiometer magnetometry in November 1985 and electro-magnetic induction (EM) in December 1985, was completed at Sites G, H, J, and L. The results of these surveys are as follows:

Site G

The magnetometry survey at Site G showed that a major magnetic anomaly area is present through most of the northern portion of the site (see Figure 4-1). Several smaller anomalies were found north of the

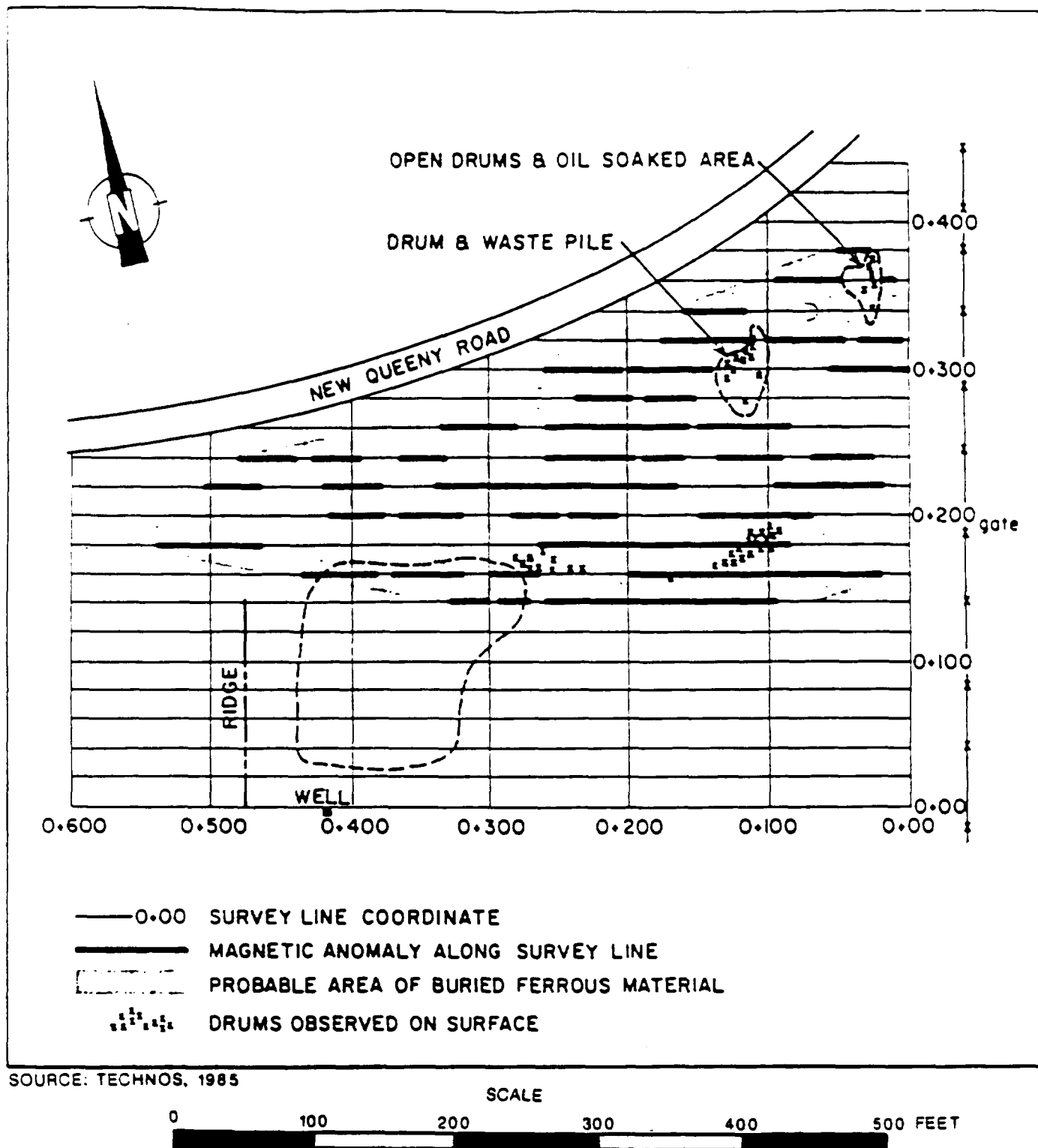


FIGURE 4-1 MAGNETOMETRY SURVEY RESULTS AT SITE G

large depression in the southwest corner of Site G. Data from survey lines that were extended into a cultivated field south of the fill area showed no magnetic anomalies. The mounds in the northwest corner of the site produced small anomalies at the surface and larger anomalies at depth, indicating significant quantities of buried ferrous metals.

An EM survey was also conducted along the grid used for the magnetometry investigation. Results from shallow soundings (approximately 0-7.5 meters in depth) revealed three areas with relatively high-intensity anomalies (see Figure 4-2). These include a 50-foot by 20-foot area in the northeast corner, a 150-foot by 100-foot area in the east-central portion, and the entire mounded area along the west perimeter of the site. Deep soundings (approximately 10 to 15 meters in depth) indicated a significant anomaly covers most of the northern portion of the Site (see Figure 4-3). Three negative anomalies were recorded in the center of the fill area, possibly indicating higher, off-scale instrument readings or the presence of significant quantities of non-conductive material such as concrete. EM values were compared to background readings of 5 to 50 millimhos recorded in the open field immediately south of Site G. Elevated magnetometry and EM values correlate with areas of waste disposal identified from historical aerial photographs and subsequent on-site soil borings in which waste was detected.

Site H

The results of the magnetometry survey indicate three large areas with major magnetic anomalies and two smaller localized areas with low-intensity anomalies (see Figure 4-4). All anomalies are large enough to indicate buried drums or a large amount of other buried ferrous metal. The southernmost large anomalous area correlated well with one of the surface depressions observed at the site, while the other two large areas partially correlated with depressions. This information, in conjunction with historical photographs, indicates that all anomalous areas are part of one large fill or disposal pit.

Further evaluation of Site H was done using EM along the grid established for the magnetometry study. Various coil spacings allowed for three different depths of penetration. Results from shallow

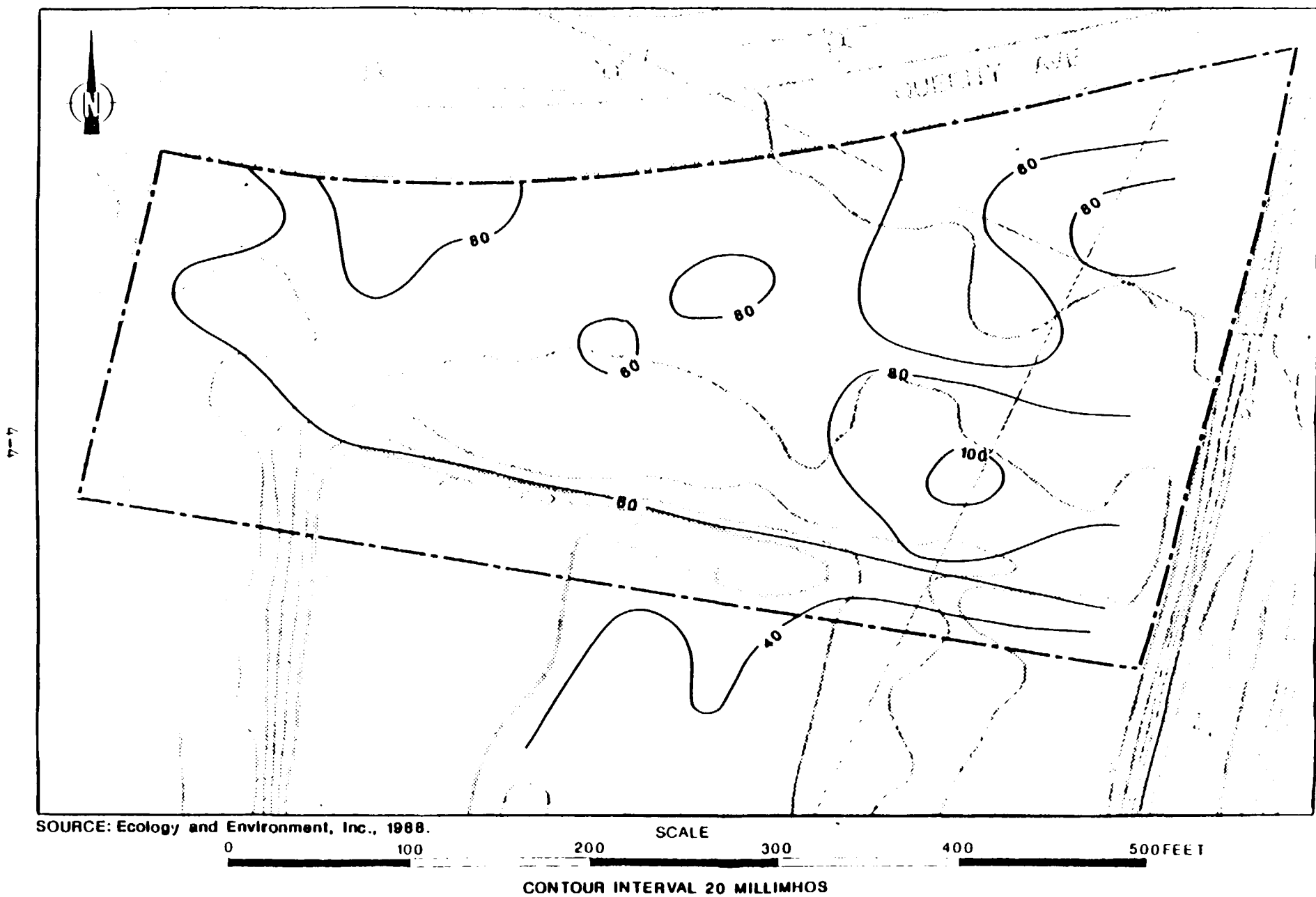


FIGURE 4-2 EM SURVEY RESULTS, 0-7.5 M DEPTH SOUNDINGS, SITE G

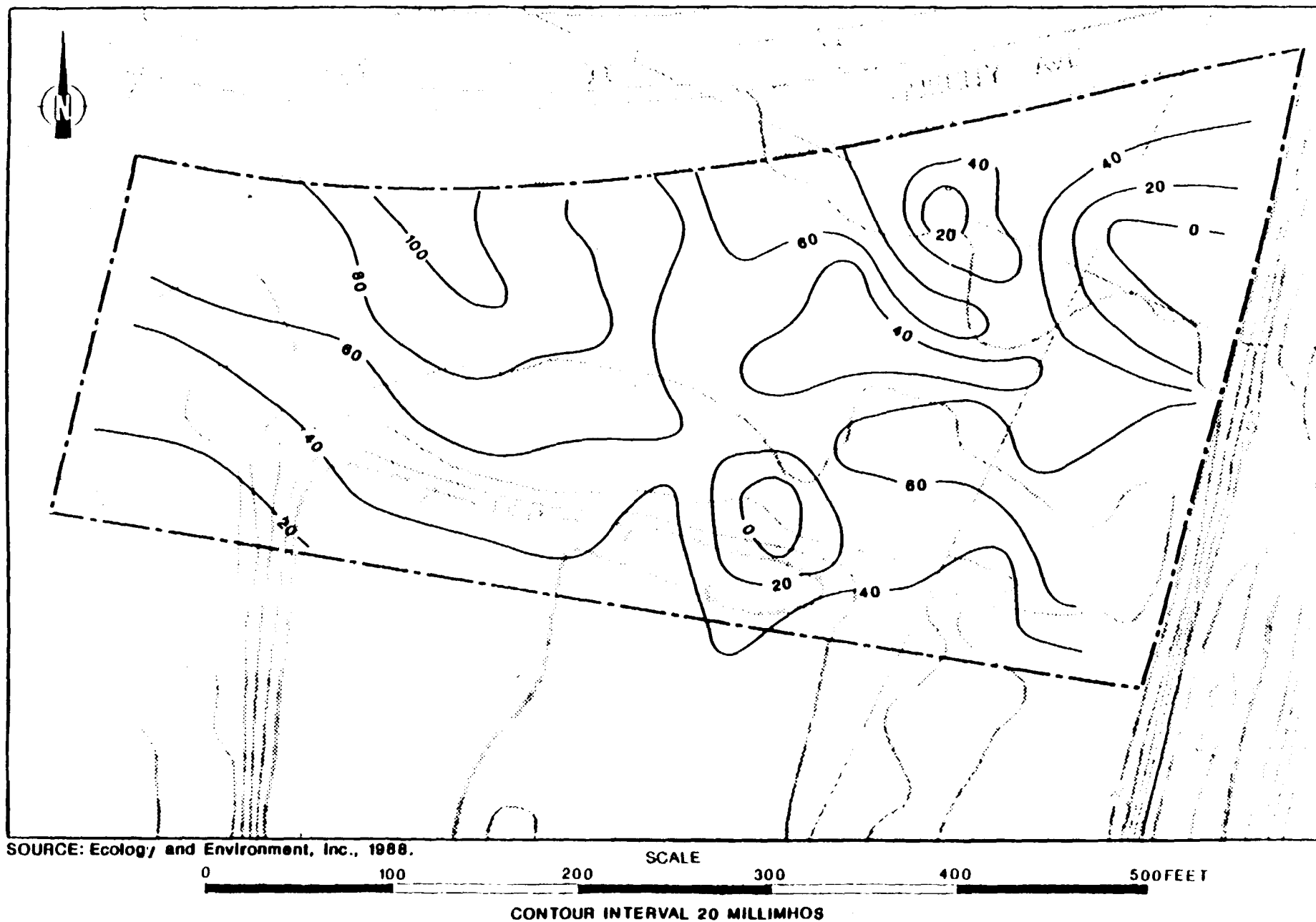


FIGURE 4-3 EM SURVEY RESULTS, 10-15 M DEPTH SOUNDINGS, SITE G

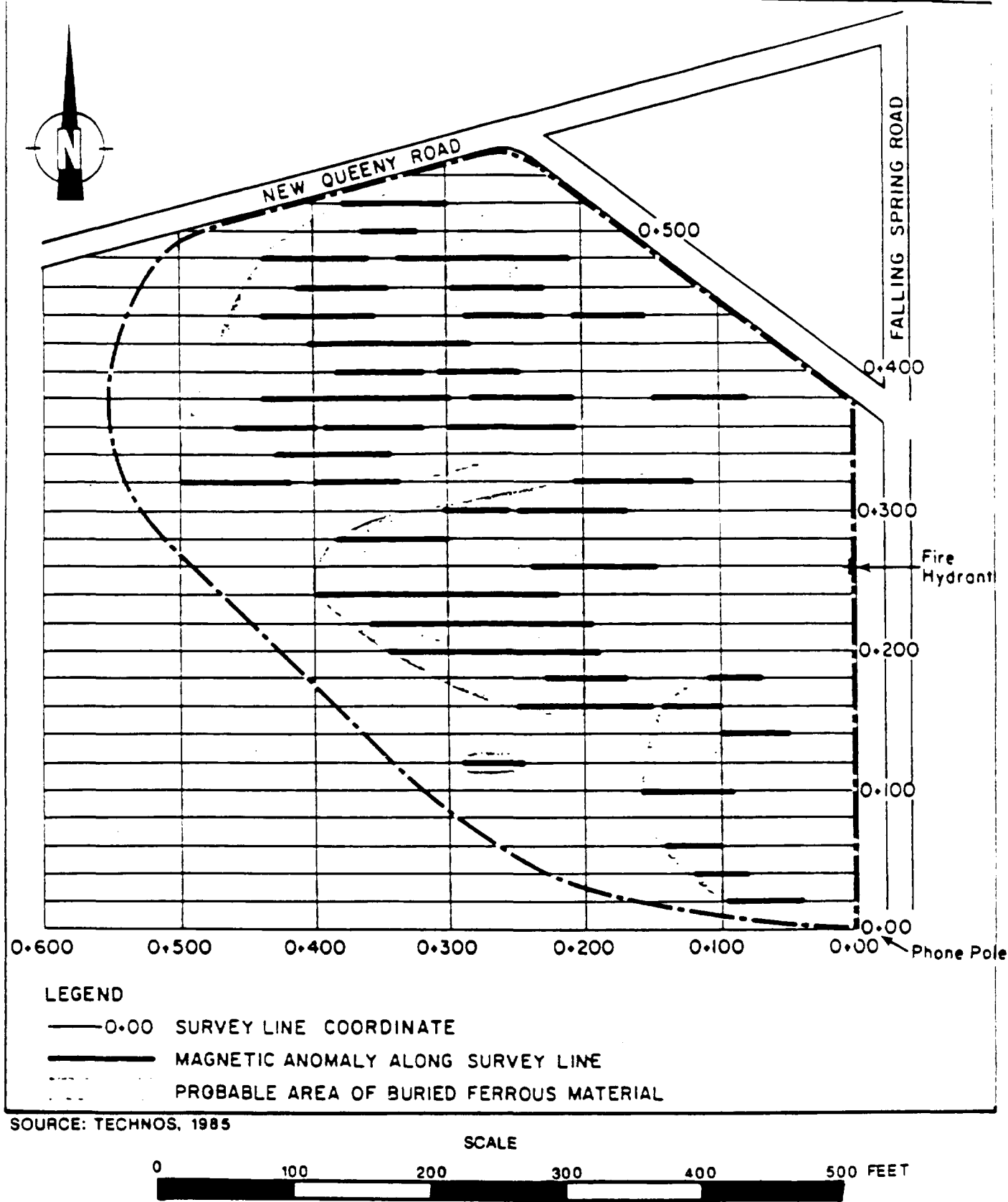


FIGURE 4-4 MAGNETOMETRY SURVEY RESULTS AT SITE H

soundings at a 0 to 7.5-meter effective depth range (see Figure 4-5) indicate three high-intensity anomalous areas which correlate with the magnetic anomalies seen in the magnetometry survey. These anomalous areas were also seen in the results from intermediate soundings at a 5- to 15-meter range (see Figure 4-6). In addition, three negative anomalies were noted near the north and central portions of the site. These negative readings indicate areas of lower conductivity, and may be attributable to relatively non-conductive contaminants (organics), or to other materials such as concrete rubble or clay. Soundings at a 12- to 30-meter range (see Figure 4-7) showed much lower conductivity readings over the entire site. These findings indicate that disposal may have been generally limited to a depth of less than 15 meters.

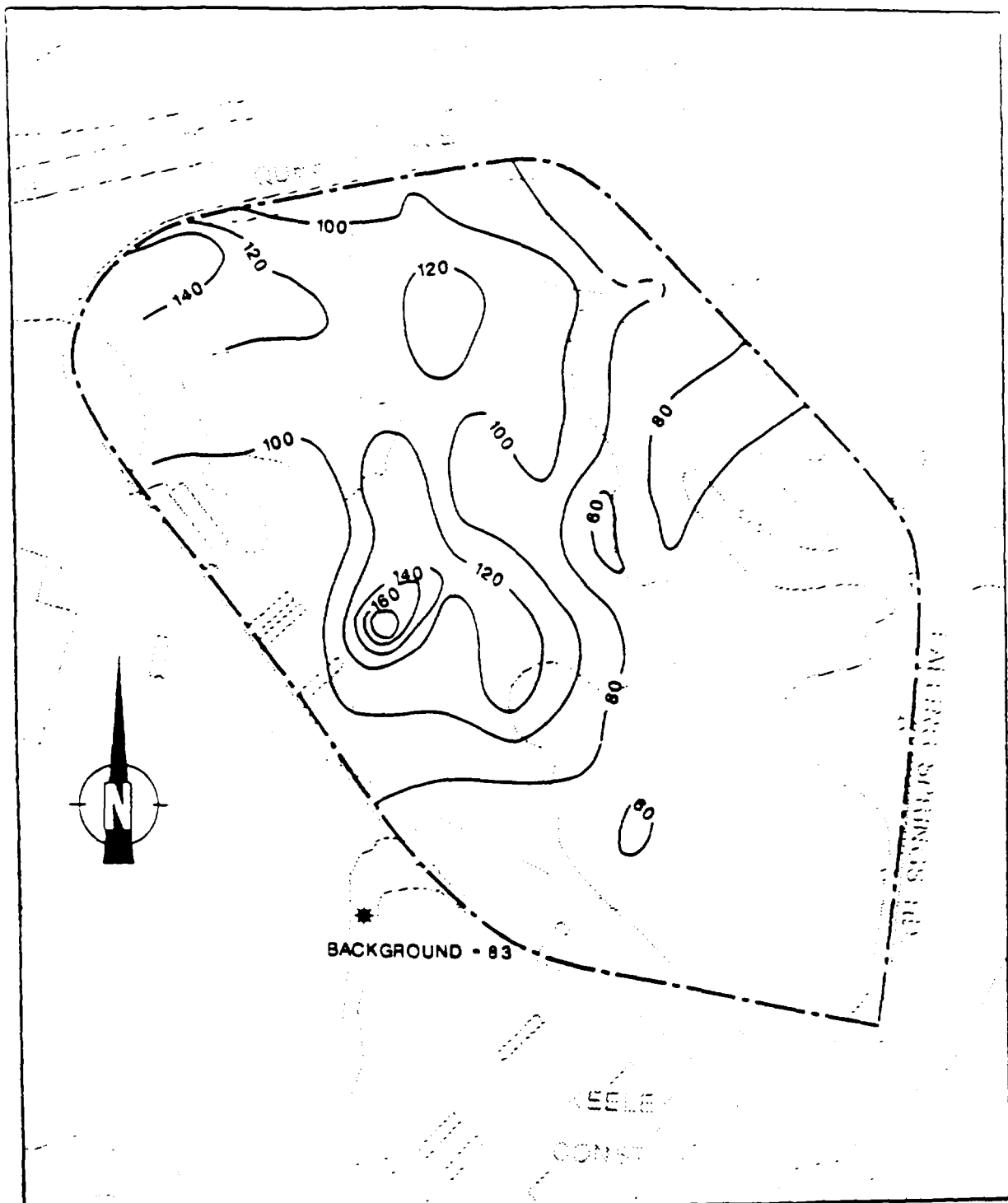
Site J

The magnetometry survey results indicated no significant anomalies within the survey area described in Section 3.2. Several small anomalies did appear, but these were not large enough to indicate buried drums. On-site observations suggest that these smaller anomalies may be a result of buried slag or interference from steel castings and scrap metals which are stored adjacent to the survey area.

An EM survey was conducted using the same grid system used for the magnetometry study. However, several survey points were offset due to physical limitations (coil spacings for the EM were changed, depending on desired penetration, thus necessitating offsets). Analysis of the EM data for both horizontal and vertical dipoles (10-meter spacing) indicate an elongated, elliptical-shaped anomaly southeast of the unlined pit. This anomaly dissipates to the north and is probably attributable to the stockpiled castings and scrap.

Site L

Results from the magnetometry study indicated a magnetic anomaly in the southwest corner of the site. Another anomaly was observed between rows of heavy construction equipment parked in the area. However, an accurate assessment of the size and actual magnitude of the anomalous areas was not possible. It is believed that these anomalies are the result of surface interference from the construction equipment.

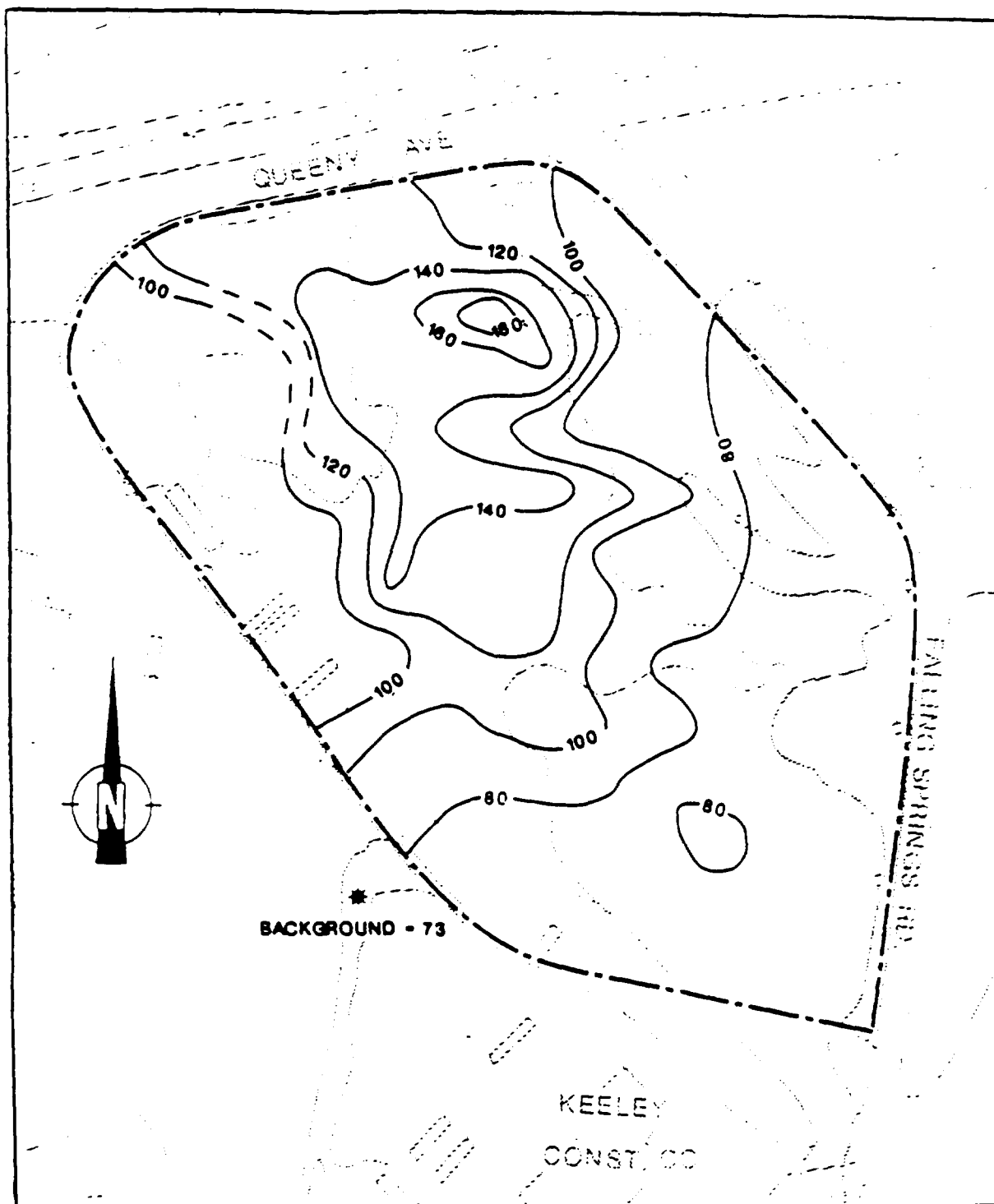


SOURCE: Ecology and Environment, Inc., 1988.

0 100 200 300 400 500 FEET
SCALE

CONTOUR INTERVAL 20 MILLIMHOS

FIGURE 4-5 EM SURVEY RESULTS. 0-7.5 M DEPTH SOUNDINGS, SITE H

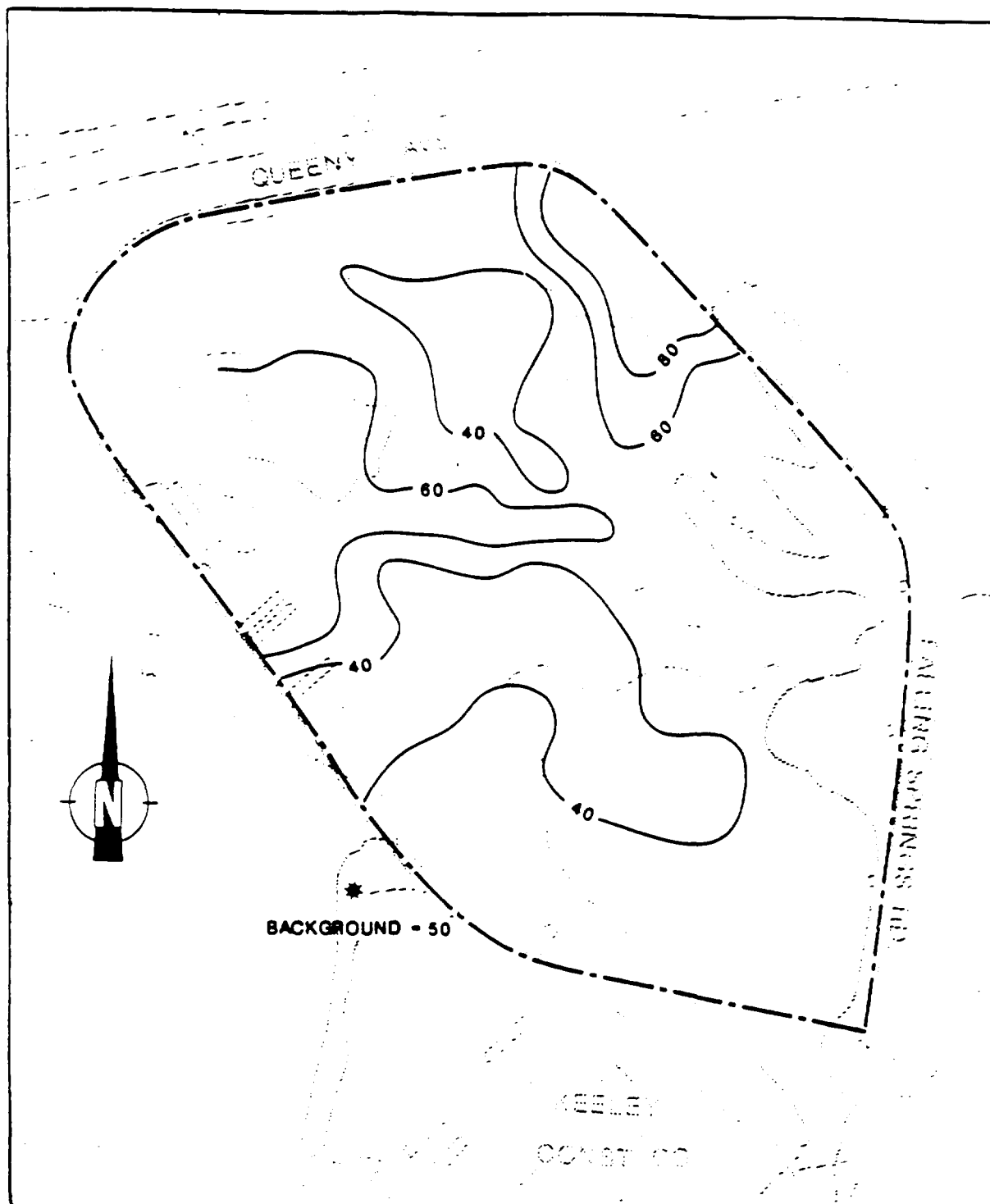


SOURCE: Ecology and Environment, Inc., 1988.

0 100 200 300 400 500 FEET

SCALE
CONTOUR INTERVAL 20 MILLIMHOS

FIGURE 4-6 EM SURVEY RESULTS, 10-15 M DEPTH SOUNDINGS, SITE H



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 4-7 EM SURVEY RESULTS, 12-30 M DEPTH SOUNDINGS, SITE H

An EM survey was conducted using different coil configurations to obtain readings from various depths. Readings at Site L showed no significant anomalies, although readings were generally higher than those obtained at a random check point in the cultivated field south of the site. These higher readings probably occurred due to the presence of cinders covering Site L but not the cultivated field. Shallow soundings indicated a single anomaly with the approximate dimensions of 150 feet by 100 feet in the southeast corner of Site L. Deeper instrument penetration showed an anomaly at a similar location; however, the size and magnitude of the readings were smaller than for the shallow investigation. Values from both penetration depths, however, were in the range expected for cinders and similar fill material (40 to 80 millimhos).

4.1.2 Site Stratigraphy and Lithology

The upper 20 to 50 feet of the unconsolidated valley fill deposits found in the American Bottoms was investigated during the hydrogeologic study in the Sauget area. Stratigraphic data presented in this section was developed from soil borings and hand auger borings at individual sites and additional data from previous investigations completed by IEPA (IEPA 1981) and USEPA FIT (USEPA 1983). Based on this information, geologic cross-sections illustrating the stratigraphy encountered at Areas 1 and 2 and Site K were developed and are presented below. Boring logs detailing the lithology at each boring location are presented in Appendix B. All stratigraphic samples were described in the field by a geologist and classified, where appropriate, into geologic formations after a review of the available literature. Stratigraphic classifications are based on descriptions by Willman and Frye (1970) of Pleistocene deposits of Illinois.

Two formations were encountered during drilling in area. They are in descending order, Cahokia Alluvium and Henry Formation.

The Cahokia Alluvium is the uppermost formation and consists of thin discontinuous beds of silt, clay, and silty sand. In the Sauget area, the alluvium is composed of loess and till eroded from the upland areas as well as sediments deposited by the Mississippi River during channel meandering and flood episodes. The type section for the Cahokia

Alluvium is found in an ISGS test hole drilled approximately 3 miles southwest of the town of Cahokia (Willivan and Frye 1970). In this boring, the Cahokia consists of 30 feet of interbedded sandy silt and clay overlying 15 feet of fine- to medium-grained silty sand. A similar sequence of strata was observed for this formation in soil borings drilled in the study area. In these borings, an average of 13 to 20 feet of sandy silt and clay deposits were found overlying silty sands. The surficial silt and clay strata appear to thin slightly with greater distance from the Mississippi River. This trend is illustrated by an average thickness of 20 feet in Area 2 and 13 feet in Area 1. In the lower portion of the Cahokia, the silty sand deposits tend to coarsen with depth although the fine- grained sand fraction appears to predominate. Sieve size and hydrometer analysis of these silty sands (IEPA 1981) also indicate that, with increasing depth, the percentage of silt decreases while sand grain size increases. This results in a nearly clean fine- to medium-grained sand in the deepest portions of the formation. Because of this, the Cahokia appears to grade almost imperceptibly into the sand and gravel valley train deposits of the Henry Formation below.

The upper portion of the Henry Formation consists of light brown to gray, fine to coarse-grained sand that becomes more coarse with depth. At many locations, bands of coarse gravel, cobbles, and occasional boulders are found at depths greater than 75 feet (Bergstrom 1956). The Henry Formation contains little if any silt-size particles, with the exception of sporadic thin silt or clay lenses, which do not affect the water-yielding characteristics of the formation. These sand and gravel deposits directly overlie the Mississippian Age St. Genevieve Limestone.

In the Sauget area, differentiation of the Henry Formation and Cahokia Alluvium deposits is not possible on the basis of mineralogical and textural characteristics or on lithologic breaks. This is due primarily to the reworking of lower Cahokia and upper Henry sands by river scour-and-fill during recent geologic time (Bergstrom 1956).

Other materials which were identified during the investigation include various types of fill material and wastes. Surficial fill materials were found at every site investigated. Materials used for fill ranged from silty clay, silt, and sand to demolition debris,

crushed gravel, and cinders. Generally, these materials appear to have been used for filling surface depressions or covering waste materials deposited in sand pits and excavations. Samples of fill collected for chemical analysis (borings G5, K1, K2, P1) indicate that this material may be heavily contaminated in certain areas. Substantial quantities of visibly contaminated waste material were identified below the surface, particularly at sites G, H, and I in Area 1. These included sludges, liquids, and solids co-mingled with refuse (e.g., wood and paper products), and stained or oily fill material. The approximate extent of these materials is illustrated in the cross-sections developed for each site and in the respective boring logs. Chemical analysis of samples is discussed in Section 4.2.4.

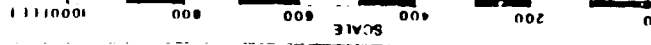
In the following sections, the strata identified at each site will be discussed in greater detail.

4.1.2.1 Area 1

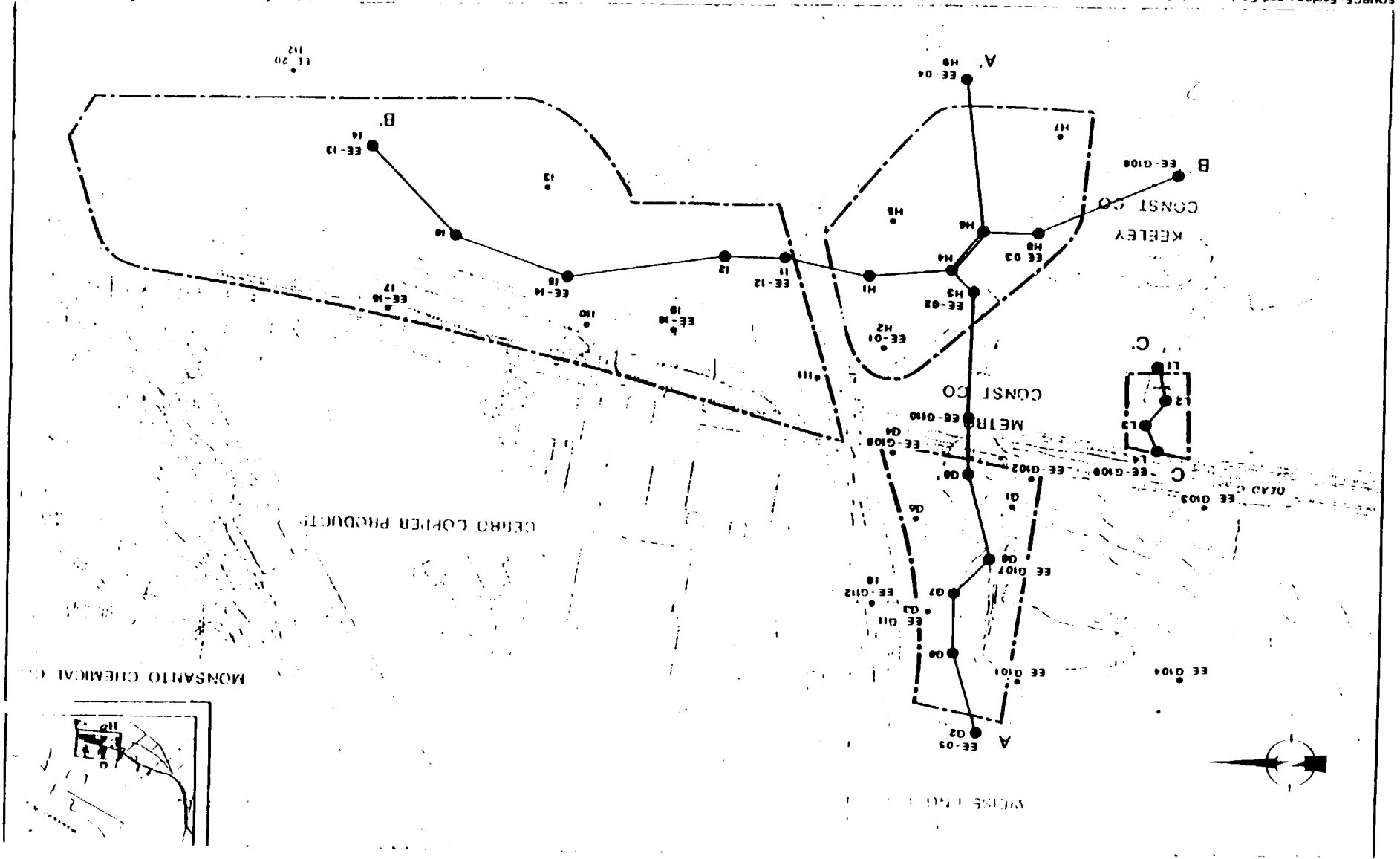
Figure 4-8 shows the location of cross-sections drawn for Sites G, H, I, and L. Cross-section A-A' (Figure 4-9) depicts the stratigraphy encountered in an east-west direction across Site G, CS-B, and Site H. Cross-section B-B' (Figure 4-10) illustrates the materials encountered in a north-south direction across Sites H and I. Figure 4-11 illustrates waste thicknesses in Sites G, H, and I. Cross-section C-C' (Figure 4-12) illustrates the materials encountered in an east-west direction across Site L.

Site G

Surficial fill materials were found to cover all of the site north of the ridge which forms the southern site boundary. Fill material generally consisted of very sandy, silty clay, mixed with cinders, slag, and occasional gravel. The thickness of the fill appears to increase from east to west across the site; approximately 3 feet of fill were found in boring G5 and 12 feet were found in boring G2. Based on calculations using the thickness of fill at soil borings, the volume of fill material across the site is approximately 22,000 cubic yards. This material appears to be a cover for the waste and refuse below. However,



SOURCE: Ecology and Environment, Inc., 1988



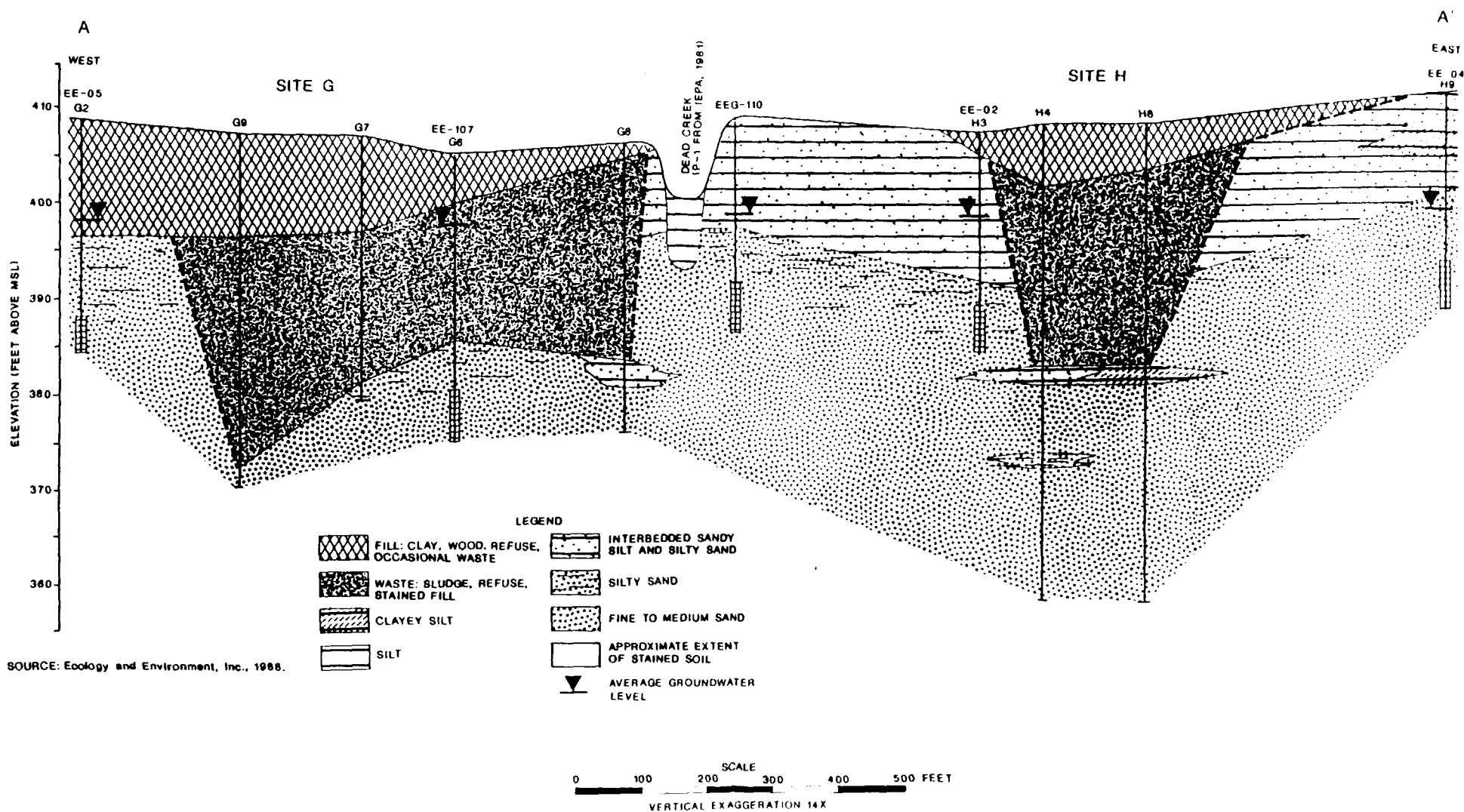


FIGURE 4-9. GEOTECHNICAL GEOLOGICAL CROSS SECTION A-A'

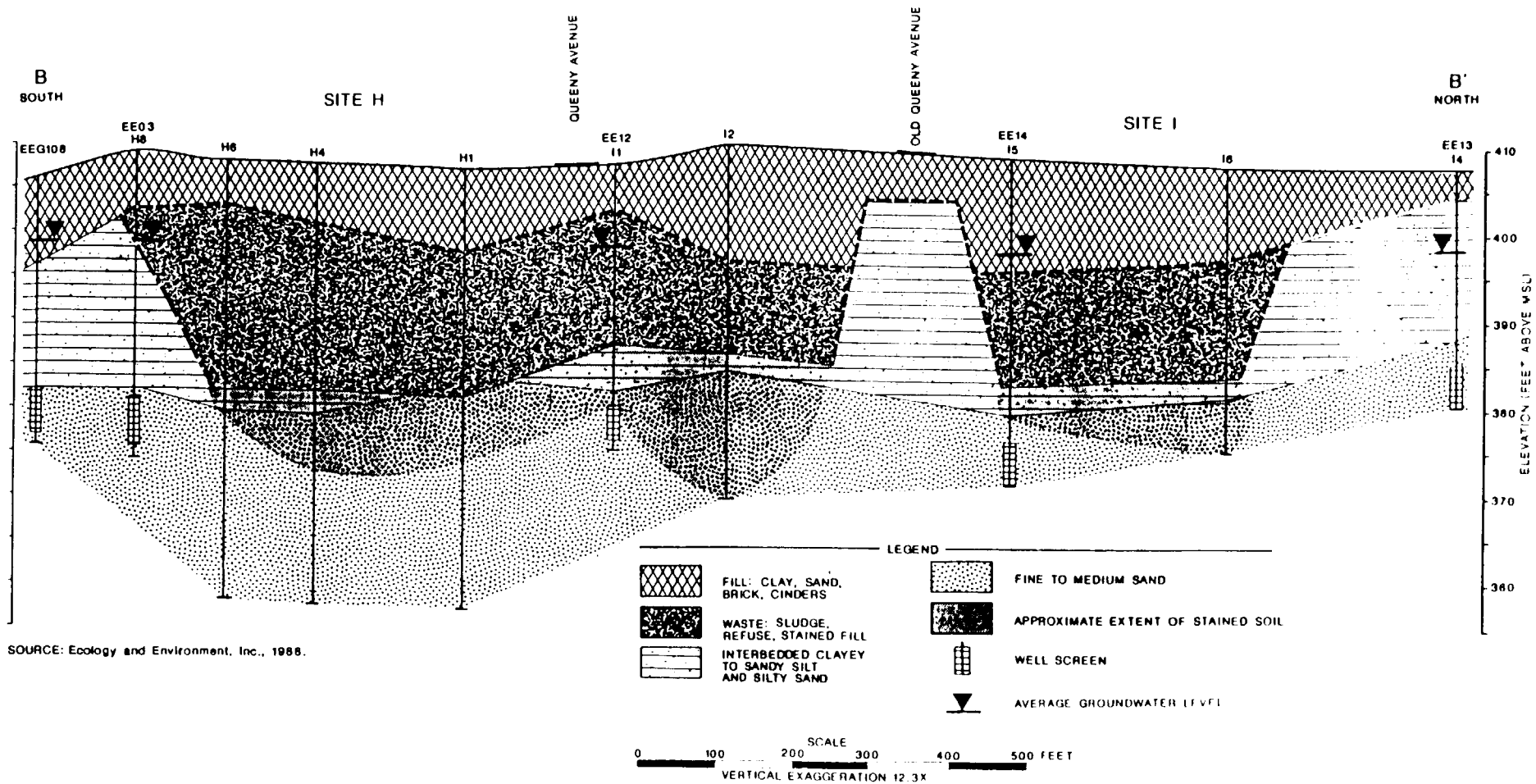
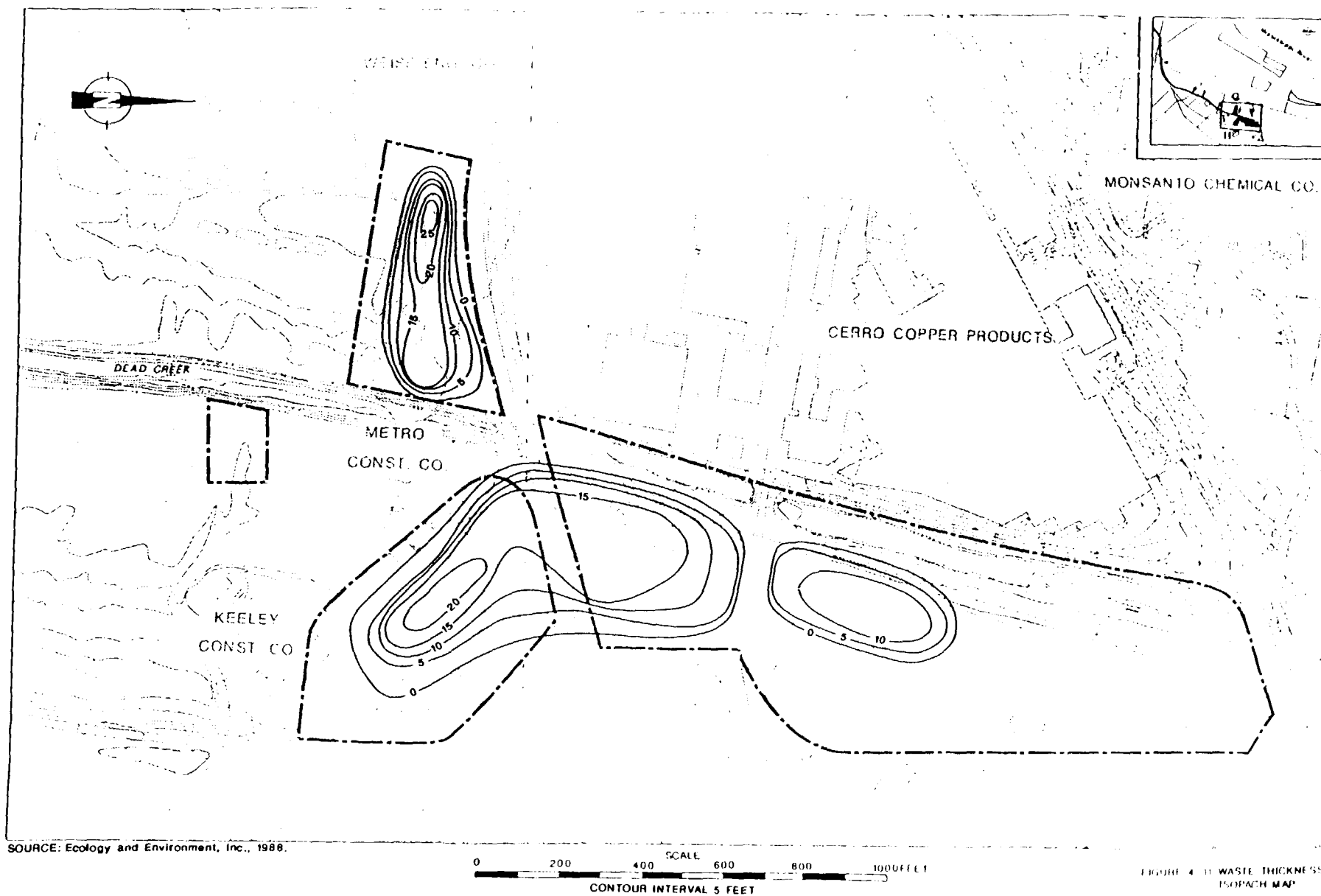


FIGURE 1-10 GENERALIZED GEOLOGIC CROSS SECTION B-B'



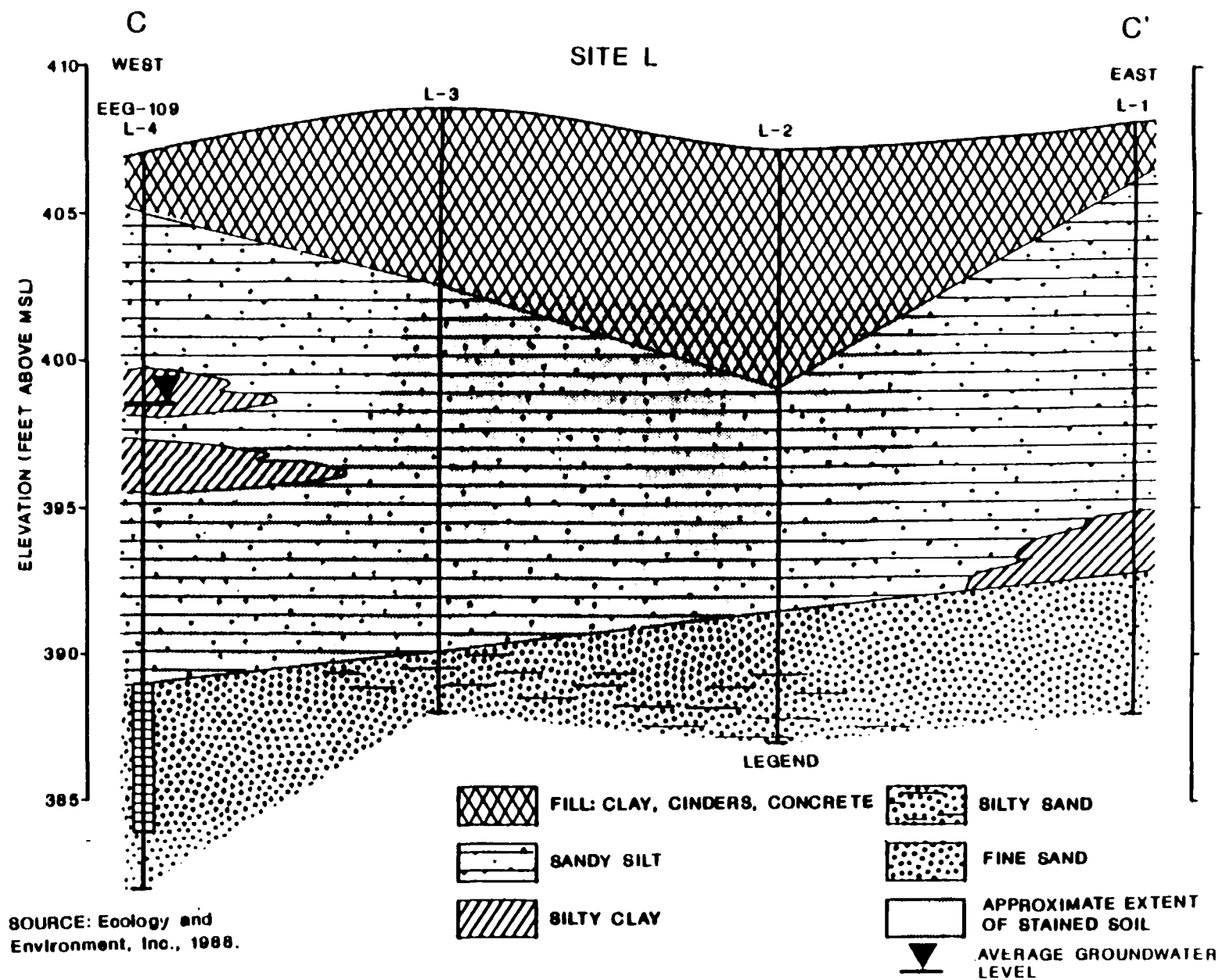


FIGURE 4-12 GENERALIZED GEOLOGIC CROSS-SECTION C-C'

recently disposed waste material, demolition debris, and refuse was also found on the surface, particularly in the eastern half of the site.

The horizontal extent and approximate thickness of waste deposits found below the fill at Site G is shown in Figure 4-11. The thickness contours were developed based on data from the soil borings. Wastes appear to have been placed in an old sand pit excavation identified in historical aerial photographs (see Figures 2-21 and 2-22).

The deepest part of the pit and the greatest thickness of waste material encountered was in boring G9, where 25 feet of black oily sludge, refuse, and unknown wastes were found directly overlying lower Cahokia or Henry formation sands. The average thickness of waste found in the remainder of the site is 15.7 feet. Based on results of boring G8, where 18 feet of waste was encountered less than 50 feet from the west bank of Dead Creek (CS-B), the sidewalls of the disposal pit are probably relatively steep. The absence of waste in borings G3 and G4 indicates that the pit probably does not extend beneath Queeny Avenue. The total volume of saturated waste material and soil within the disposal pit is approximately 60,000 cubic yards. Soil borings indicate that the disposal pit was generally excavated down to the silty fine sand deposits found near the bottom of the Cahokia Alluvium Formation. These sand deposits were found to be extensively stained below the disposal pit. However, the vertical extent of stained soil could not be determined during this investigation. At the present time, the majority of waste material at Site G is below the water table, which averages 11 feet below ground surface.

Site H

Historical aerial photographs suggested that Site H was a sand and gravel borrow pit prior to commencement of disposal activities at the site. The photographs indicated that the disposal pit also encompassed the southern half of Site I. This disposal pit has since been filled and bisected at the surface by the construction of Queeny Avenue.

Soil borings and geophysical studies conducted during the present investigation confirmed that the southern portion of this disposal pit is located within the boundaries of Site H. Data from the eight borings drilled at the site indicate that the site is covered by fill material

consisting of brown to black silty clay, mixed with crushed limestone, bricks, and cinders. The northwest corner of the site (boring H-2) is predominantly covered with cinders. Fill materials ranged in thickness from 2.5 feet (boring H3, thought to be just outside the disposal pit area) to 13 feet (boring H5). The presence of fill at all eight boring locations suggests that the entire site has been reworked to some degree by activities associated with the disposal pit. Chemical analysis of fill from boring H5 (see Section 4.2.4) also suggests that the fill material may be contaminated at some locations. However, visible evidence of contamination was not generally observed in the fill during drilling. Based on the thickness of fill found in each boring, the volume of fill at Site H is approximately 66,000 cubic yards.

Visibly contaminated waste materials were found underlying the fill over a major portion of the site. This is illustrated in cross-sections A-A' and B-B' (Figures 4-9 and 4-10, respectively). Wastes consisted of varicolored sludges, solids, and oily refuse. The approximate thickness of these materials is shown in Figure 4-11. Based on boring results, the maximum depth of the disposal pit is estimated to be 26 feet below ground surface (at boring H4). Chemical wastes and sludges were identified primarily in borings H4 and H6, while oily refuse and fill were found in H1. Oily, black stained wood predominated in boring H2.

The excavation of the disposal pit at Site H appears to have been similar to the excavation of the pit at Site G. Both pits appear to have been excavated down to the bottom of the Cahokia Alluvium or into the top of the Henry Formation. Sands and silts from these formations were visibly stained to a depth up to 10 feet below the bottom of the disposal pit.

Most of the waste materials within the pit are presently below the water table, which averages 10 feet below ground surface. Based on the thickness of waste material at each boring, the volume of saturated waste material and contaminated soil is approximately 110,000 cubic yards in Site H.

Site I

Data from borings I1, I2, I9, and I11 at Site I, in conjunction with historical aerial photographs, confirmed that the disposal pit at

Site H extends below Queeny Avenue to include the southern half of Site I. The location of a second disposal pit, north of the access road to Cerro Copper Products (formerly Old Queeny Avenue), was also confirmed by borings I5 and I6. Aerial photographs indicate that neither pit extends beneath the access road. The extent and thickness of wastes found in both pits is shown in Figures 4-10 and 4-11.

In general, fill material covers most of the site. The fill consists of brown to black sandy clay, mixed with gravel, slag, and occasionally asphalt. Crushed limestone gravel was used at the surface in the southern half of the site to support tractor trailer traffic, while in the northern half, sporadic piles of construction debris, concrete, and wood have been scattered around the site. Surficial fill material found in soil borings ranged in thickness from 3 feet at boring I4 (outside the disposal pit areas) to 13 feet covering the disposal pits at borings I2 and I5. The volume of fill is estimated to be 50,000 cubic yards.

Waste materials found below the fill in both pits consisted of oily sand, clay, wood, and cinders mixed with other refuse such as cardboard, rubber, and cloth. Sludge-like material was also found in both pits. Based on soil boring data, the depth of the pit north of the access road is approximately 26 feet. The pit south of the access road is at least 23 feet deep. Waste materials were encountered in borings I1, I2, I5, I6, I9, and I11. The total volume of saturated waste material and contaminated soil in both pits is estimated to be 140,000 cubic yards. Both pits appear to terminate in fine sand and sandy silt deposits characteristic of the lower portion of the Cahokia Alluvium. These materials were stained below both pits.

Creek Sector A is also located within the boundaries of Site I. This section of the creek contained what appeared to be nearly stagnant water during the whole period of the investigation. Sediment samples collected from both the northern and southern portions of CS-A consisted predominantly of sandy silt, suggesting that the creek bottom may be heavily silted along its entire length. Water within the creek consistently appeared oily with a heavy oily scum observed on the water surface near the interceptor pipe at the north end. Samples of both

creek water and sediment contained significant organic contamination (see Section 4.4.2.1).

At the present time, waste materials within the two pits are below the water table, which averages 10 feet below ground surface.

Site L

Site L is the location of a former surface impoundment used by the Harold Waggoner Company to dispose of wash water from a tank truck cleaning operation. Figure 4-8 shows the location of four soil borings drilled at Site L. A geologic cross-section was developed based on these borings, and is shown in Figure 4-12.

Data from the borings indicate that the surface impoundment was a shallow excavation, approximately 8 feet deep. This impoundment extended into the sandy silt deposits of the upper Cahokia Alluvium. Borings L2 and L3 are believed to be located within the confines of the old impoundment. In these borings, 5 to 8 feet of fill material consisting of black cinders, clay, concrete, and brick overlies loose sandy to clayey silt, which grades to silty fine sand at approximately 17 feet. The contact between fill material and silt is believed to represent the bottom of the excavation. The silt and sand deposits were found to be extensively stained from approximately 5 feet to the termination of the borings at 20 feet.

Borings L1 and L4 were positioned outside of the old impoundment. In boring L1, 2.5 feet of cinders and asphalt fill material was found overlying upper Cahokia silt and sand deposits. However, no staining was observed in these deposits. Geologic strata encountered in boring L4 was similar to that of L1, with the exception that in L4 black-stained deposits similar to those found in L2 and L3 were observed from approximately 10 to 17.5 feet; no stained deposits were found in L1. The fact that staining was not observed until the water table was encountered at approximately 10 feet suggests that liquids disposed in the old impoundment infiltrated downward until encountering the water table. Liquids then acquired a horizontal component of flow, moving in a westerly direction with the predominating direction of groundwater flow. No lining was observed for the impoundment, indicating that liquids dis-

charged from the tank trucks were allowed to drain by infiltration into the soil and subsequently into the groundwater below the site.

Creek Sector B

The northern half of Creek Sector B (CS-B) is included as part of Area 1 due to its proximity to Sites G, L, and CS-A, and because of the apparent contributions of these sites to the contamination identified within the creek. The geology and chemical contamination of CS-B was extensively investigated by the IEPA during its September 1980 hydro-geologic study of the creek and vicinity (IEPA 1981). Results of that investigation indicate that the creek at one time flowed at a sufficient velocity to erode through the silt and clay deposits of the upper Cahokia Alluvium into the fine sands and silty sands typically found at the base of the Cahokia. As the velocity of the creek decreased over time, the scour channel that had formed filled with the clayey silt and other fine-grained deposits that compose the creek bed today.

A cross-section of the creek bed derived from data from the IEPA report is shown in Figure 4-9. The present clayey nature of the creek bed also appears to be the result of erosion and slumping of clayey silt from the steep banks of the creek. Numerous deep gulleys have been eroded beneath the fence along the west bank of the creek as a result of runoff from the Metro Construction Company property. Another factor which has affected the nature of the creek bed is the past discharge of rubbery wastes from a former outfall from the Midwest Rubber Company. Previous discharges from this pipe have produced a sponge-like effect in surface soils downstream of the pipe.

In the northern half of CS-B, water appears in the creek following precipitation events. Because the gradient of the creek bed is extremely slight, varying only 1.35 feet in elevation from Queeny Avenue to Judith Lane to the south (IEPA 1981), water appears to stagnate in small surface depressions and a shallow channel that has formed in the northern half of CS-B. Following a heavy rainfall, runoff to the creek flows downstream at a slow rate until it backs up at the blocked culvert below Judith Lane. Evaporation is probably the major cause of water loss in the northern half of CS-B. The fine-grained clay and silt materials of the creek bed, along with the rubbery

waste material found at the surface of the creek bed in this section, suggest that infiltration of water into the subsurface is limited. In the southern half of CS-B, water losses due to infiltration may be greater as a result of the higher levels of ponded water. Leakage through the culvert may also contribute to water losses. At the present time, water loss rates from any of these factors are unknown.

4.1.2.2 Peripheral Sites

The investigation of Sites J, K, N, and P was limited to the drilling of soil borings and collection of subsurface soil samples. A geological cross-section was developed for Site K to investigate the location of stained soils below the surface. Cross-sections for the remaining sites were not developed because the boring data were insufficient or because significant layers of waste and stained soils were not encountered.

Site J

Three soil borings were drilled at Site J. Borings J1 and J2 were drilled in the surface disposal area north of the Sterling Steel foundry; boring J3 was drilled near the borrow pit southeast of the foundry (see Figure 3-9). The surface disposal area behind the plant appears to have been used for the disposal of spent foundry sand, slag, and construction debris. Historical aerial photographs and soil boring results indicate that no excavation occurred in this area prior to commencement of disposal activities.

In boring J1, 4 feet of fill material consisting of black foundry sand, rock, and brick fragments was found overlying silty clay and sandy silt of the Cahokia Alluvium. Boring J1 was terminated at a depth of 20 feet. No visible contamination was observed.

In boring J2, similar fill material was found to a depth of 6 feet. Below the fill, silty clay and sandy silt deposits were encountered to a depth of approximately 22 feet, where a medium to coarse, well sorted sand (possibly Henry Formation) was encountered. Borehole monitoring with an HNu indicated that this sand was contaminated with volatile organics from 22 feet to boring termination at 25 feet. Subsequent chemical analysis of this sand (see sample results for J2-12, Section

4.2.4.1) showed the presence of numerous organic contaminants. The source of these compounds may be leaks or spills from the Mobil Oil Company tank farm located immediately east of the site.

Boring J3 was drilled approximately 15 feet south of the open pit located southeast of the foundry. In this boring, 8 feet of fill material consisting of foundry sand, sandy clay, and brick was found overlying 10 feet of foundry sand and slag. Below this, brown to gray medium-grained sand was encountered from 18 to 25 feet. Groundwater was encountered approximately 15 feet below ground surface. Boring J3 was terminated at 25 feet. A sample of foundry sand from 10 to 20 feet was submitted for chemical analysis (see sample results for J3-13, Section 4.2.4.1). Visibly contaminated soils were not observed in this boring.

Site K

Site K is the location of a former sand pit which may have been used for waste disposal operations beginning sometime in the late 1940s. The pit has since been filled and covered with soil and gravel, and the area has been graded to the surrounding topography. Three 20-foot borings were drilled at Site K, and a subsurface sample from each boring was collected for chemical analysis. The location of borings at Site K are shown in Figure 4-13. Data from these borings are depicted in geologic cross-section D-D (see Figure 4-14). In general, 10 to 15 feet of fill, consisting of a mixture of brown silty clay, sand, and rock or brick fragments, was found overlying discontinuous layers of fine to coarse sand and silty clay. The substantial thickness of fill encountered indicates that all three borings were located within the pit area seen on historical aerial photographs. Although waste materials were not observed, black-stained soils were observed in each boring near the bottom of, or immediately below, the fill material. Water was encountered at 7 to 10 feet below the surface in each boring.

Site M

Investigations at Site M were confined to a soil gas survey and sediment sampling described in Sections 3.3 and 3.4, respectively.

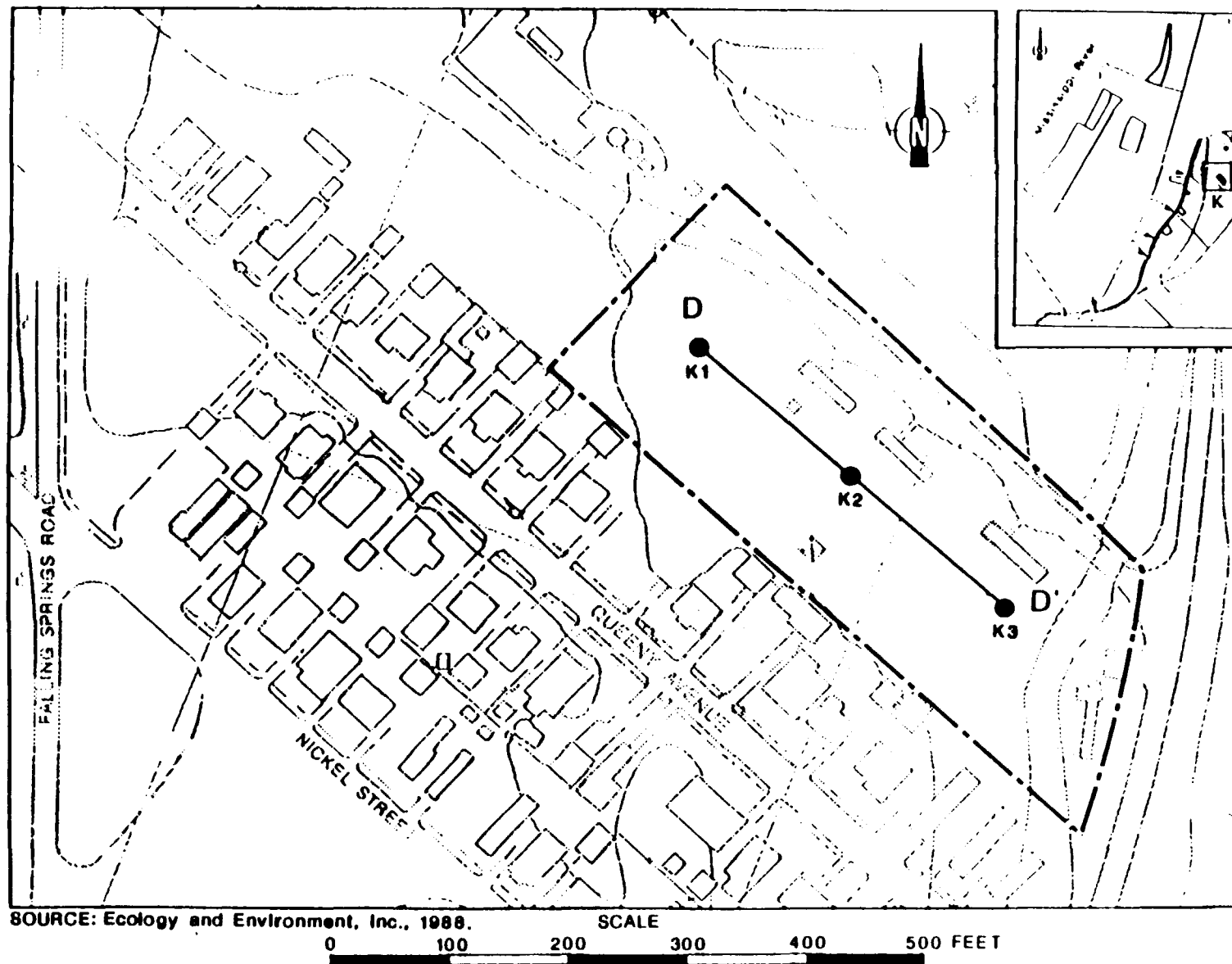


FIGURE 4-13 GEOLOGIC CROSS-SECTION D-D' LOCATION MAP

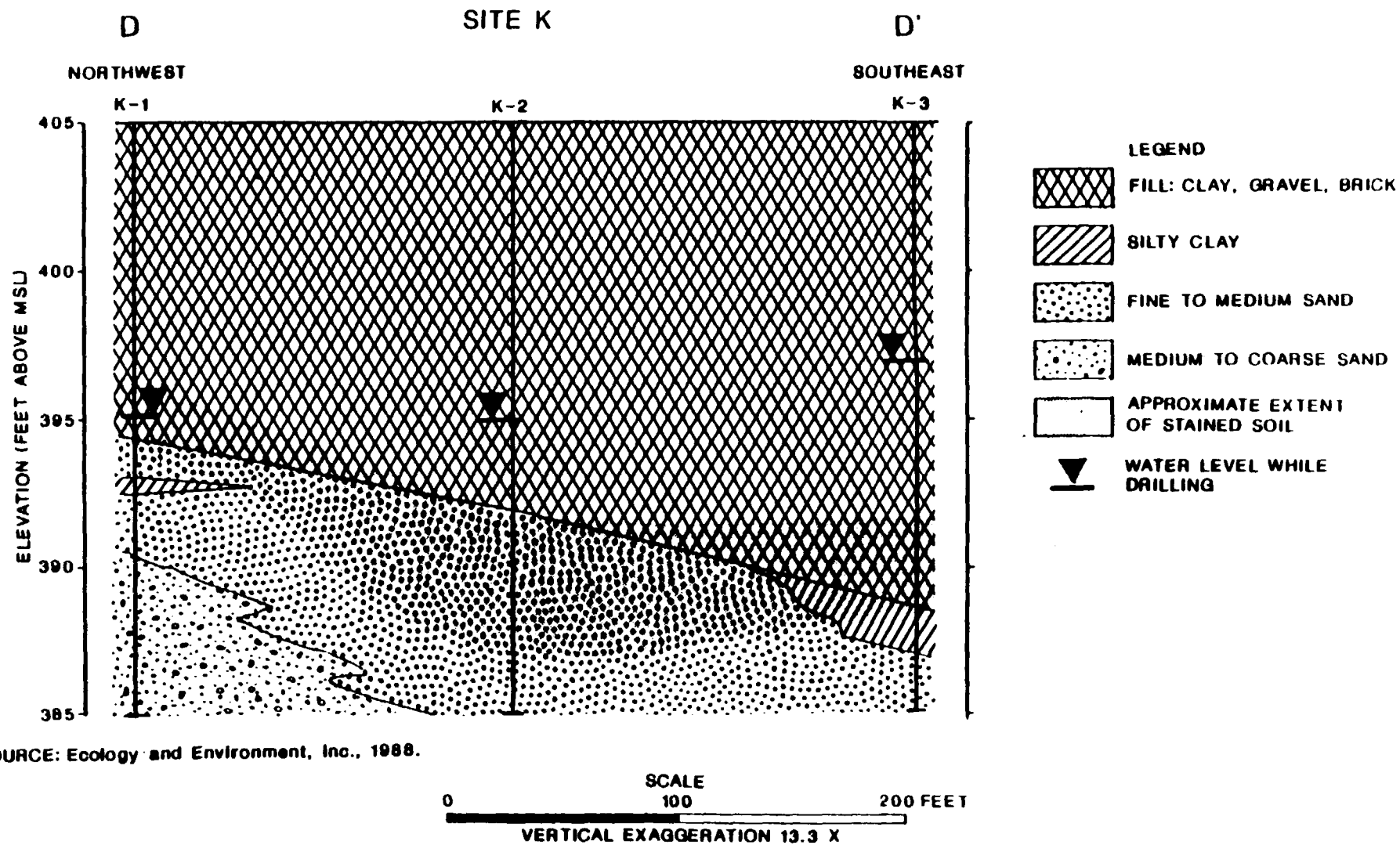


FIGURE 4-14 GENERALIZED GEOLOGIC CROSS-SECTION D-D'

Site N

Site N is a borrow pit which may have been used for waste disposal. The pit was excavated for road construction materials and has since been partially filled with concrete, rubber, and other demolition debris. Two borings were drilled at Site N (see Figure 3-11). Boring N1 was drilled to a depth of 20 feet. Approximately 2 feet of crushed gravel and fill material was found overlying 18 feet of interbedded silty sand, sandy silt, and fine sand, typical of the Cahokia Alluvium. Waste material was not observed in this boring. However, black and reddish-brown staining was noted on silt and sand samples from 6 to 10 feet. Screening of these samples with an HNu showed readings slightly elevated (2 to 15 ppm above background). A composite sample (N1-05) from 0 to 10 feet was collected for chemical analysis.

In boring N-2, fill material was found to a depth of 10 feet. Below the fill was approximately 3 feet of sandy silt, followed by an extensive deposit of fine sand. This sand, coarsening with depth, was present to boring termination at 40 feet. No waste material or unnatural staining was observed. A subsurface sample (N2-06), consisting of the silt and sand found immediately below the fill, was submitted for chemical analysis. Groundwater was encountered approximately 1 foot below the ground surface, due to the location of the borings at a relatively low elevation within the pit, which is only partially filled.

Site P

Site P is an inactive, IEPA-permitted landfill which was allowed to accept only nonchemical waste from Monsanto and other companies in the Sauget area. Although the permit stipulated only nonchemical waste, IEPA files contain several reports of hazardous waste disposal at the site. Five 30- to 40-foot borings were drilled to investigate subsurface conditions at this site (see Figure 3-12). Three composite subsurface samples and a duplicate were collected from the borings for chemical analysis. Analytical results are discussed in Section 4.2.4.3.

Data from the soil borings indicate that fill material consisting of silty clay, cinders, slag, and refuse has been disposed directly on the land surface. The thickness of fill ranges from 13 feet at boring P1 to 28 feet at boring P2. In general, the surface of the site is

covered with 1 to 2 feet of cinders and slag. Fill material was observed at all five boring locations. With the exception of P1, fine- to medium-grained sand was found immediately below the fill in each of the borings. This sand was present to boring termination at 30 to 40 feet. In P1, 5 feet of brown silty clay was found below the fill prior to the fine- to medium-grained sand. The absence of clay and the relatively greater thickness of fill at other boring locations suggests that clay materials may have been scraped from the surface or reworked to incorporate debris when disposal was initiated.

Significant waste material layers were generally not observed; however, the fill materials may be contaminated to some degree. For instance, in boring P1 an odor similar to that of lubricating oil was noted in a split-spoon sample taken from 3.5 to 5 feet. A composite of this sample and split-spoon samples from 0 to 10 feet in borings P2, P3, and P4 (sample P1-53) was submitted for chemical analysis.

Groundwater was encountered in the sand deposits found below the fill at depths which generally ranged from 25 to 30 feet.

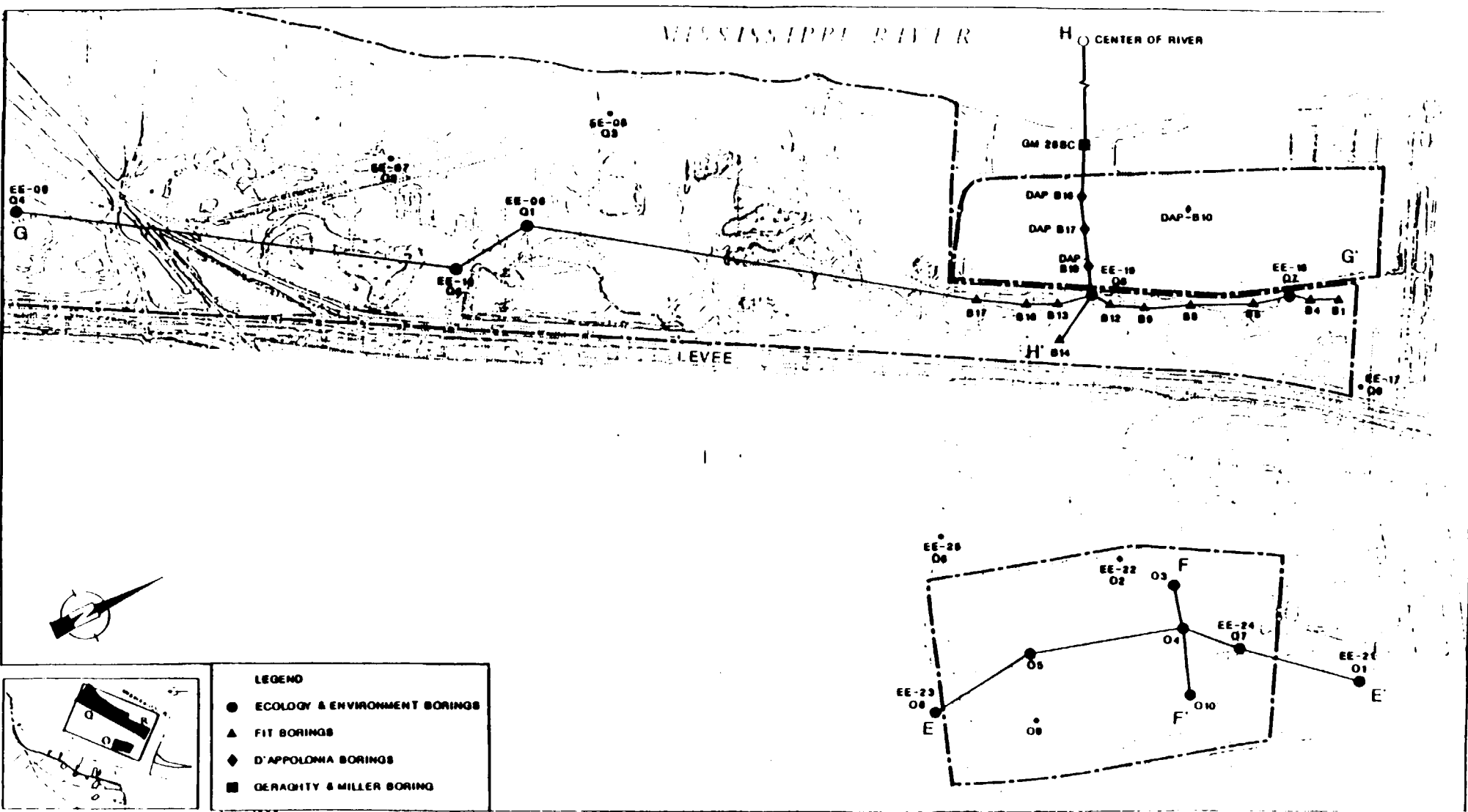
4.1.2.3 Area 2

Figure 4-15 shows the locations of borings and geologic cross-sections developed for Area 2 Sites O, Q, and R. Boring data from D'Appolonia (1980) and Geraghty & Miller (1986) were used to develop the cross-section for Site R (see Figure 4-15). USEPA-FIT (E & E 1983) data were used to supplement DCP boring data to develop the geologic cross-sections for Site Q.

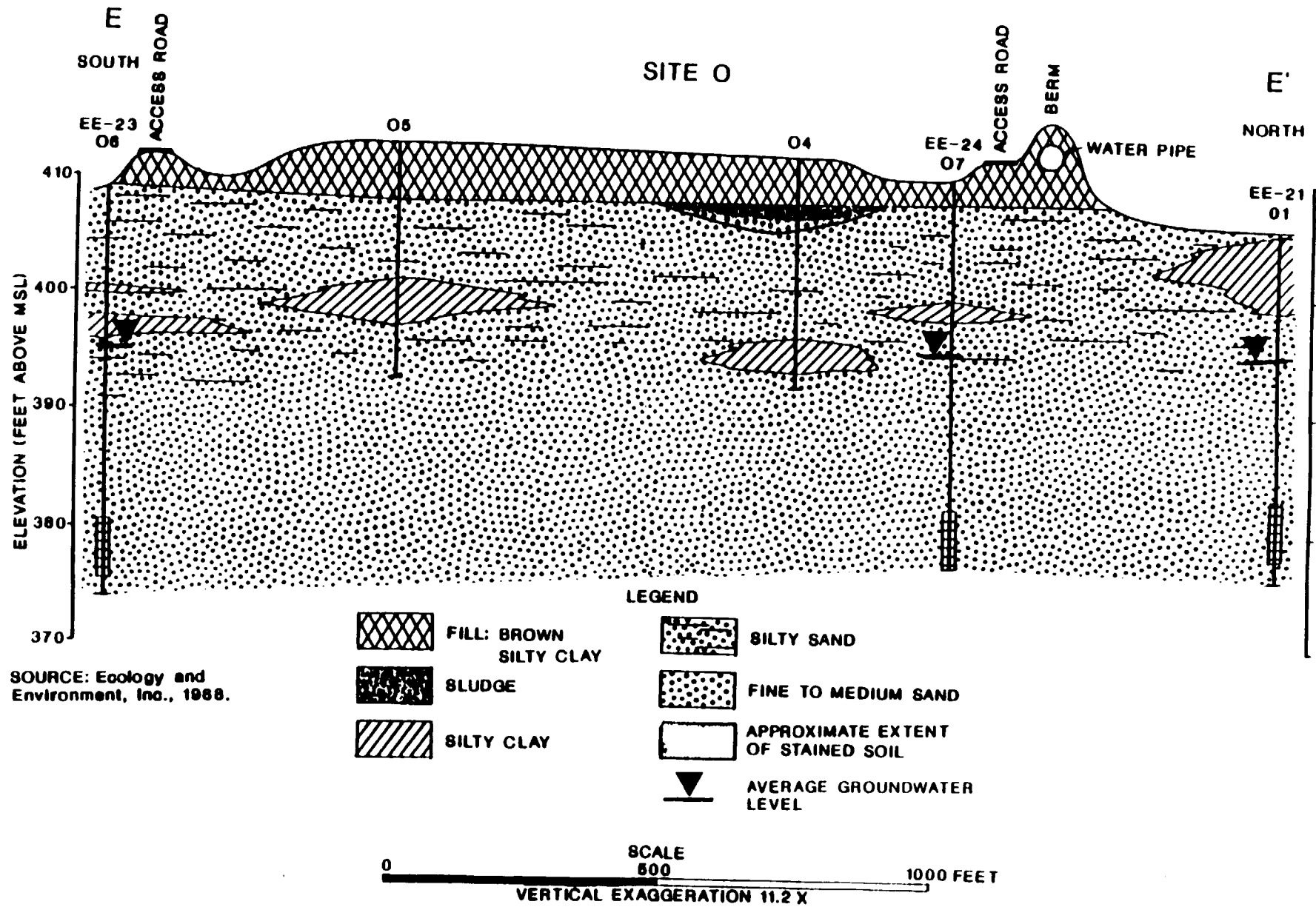
Site O

The hydrogeologic investigation at Site O focused on the four inactive sludge dewatering lagoons located south of the Sauget Waste Water Treatment plant. Ten borings, ranging in depth from 14 to 35 feet were completed within and around the site (see Figure 4-15). Results of these borings are illustrated in cross-sections E-E and F-F', in Figures 4-16 and 4-17, respectively.

The lagoons have been capped by a brown silty clay fill which ranges in thickness from 1 foot in boring O10 to 7 feet in boring O2. The access road/water main berm which runs roughly north and south above



SOURCE: Ecology and Environment, Inc., 1988.



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 4-18 GENERALIZED GEOLOGIC CROSS-SECTION E-E'

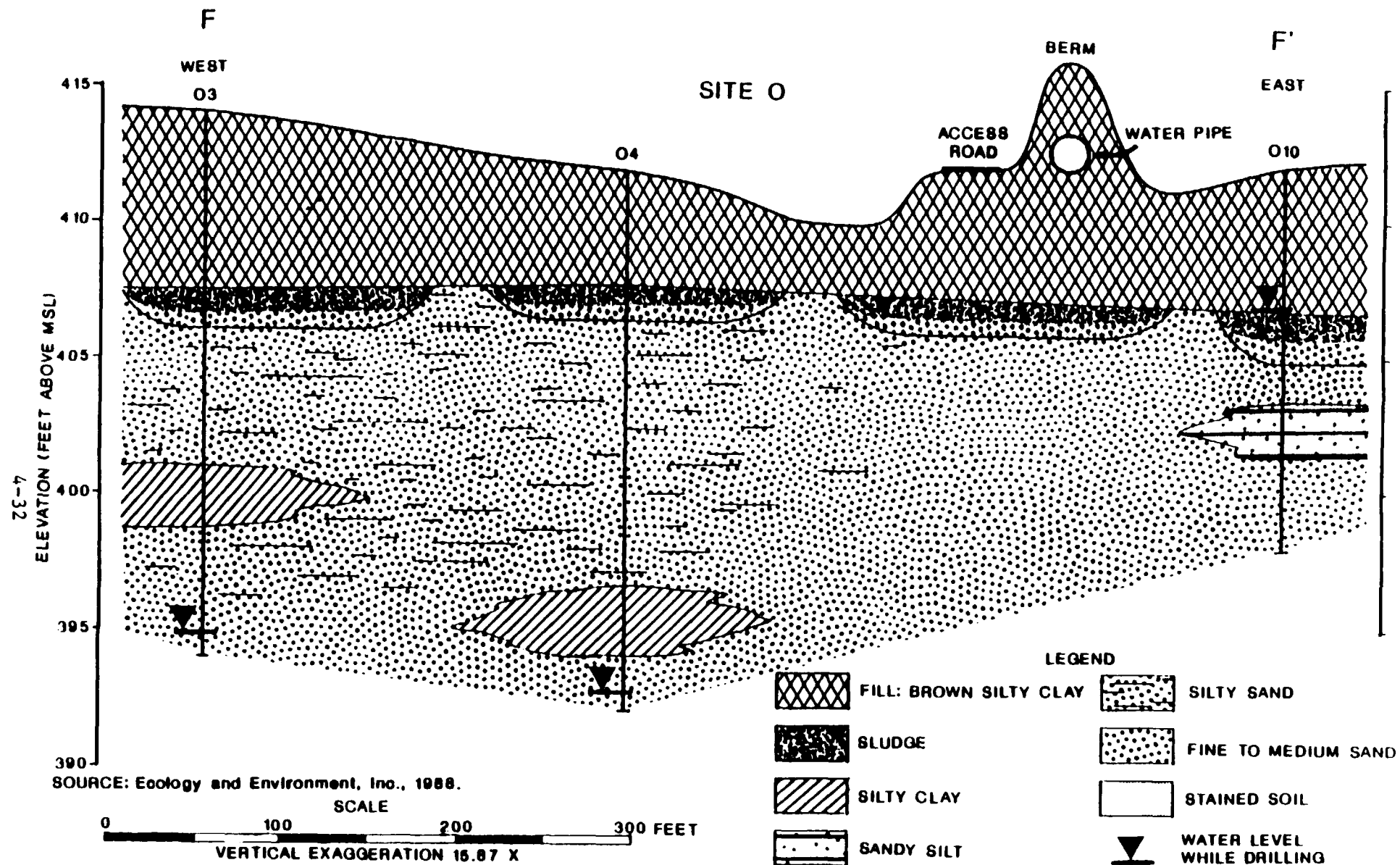


FIGURE 4-17 GENERALIZED GEOLOGIC CROSS-SECTION F-F'

lagoon 2 is also thought to be constructed with similar material. Borings 03, 04, 05, 09, and 010 were drilled in an attempt to penetrate lagoons 1, 3, and 4 which were identified from historical aerial photographs. Approximate lagoon boundaries are shown in Figure 2-5. Results from these borings indicate that much of the sludge material was probably removed prior to capping. However, some sludge or sludge and lime-neutralized material was found in three of these five borings. In boring 03, 6 inches of a black, spongy tar-like substance was observed from 6.5 to 7 feet below the surface, above another 6 inches of stained clay. In boring 04, a black sandy, clay-like material, interpreted to be stabilized sludge, was found from 4.5 to 5.5 feet with staining also observed in the sand deposit under this material. In boring 010, 1 foot of silty clay cap materials was found overlying 4 feet of cinders. Approximately 2 feet of saturated black and green sludge was observed below the cinders. The sand and silt found immediately below this material was extensively stained to a depth of 10 feet.

Visible contamination was not observed in boring 05 which may have been located, inadvertently, between lagoons 2 and 3. No sludge was found in boring 09, although black and orange staining, along with an oily sheen, was observed on silt and sand deposits to a depth of 15 feet.

The general stratigraphy of Site 0 is represented in boring 07 where 2 feet of fill overlie 13 feet of discontinuous silt, clay, and silty sand layers which gradually grade into a clean (silt-less) water-bearing fine- to medium-grained sand at 15 to 20 feet below the surface. Water levels in wells screened within this clean sand averaged 14.5 feet below the surface.

Site Q

Site Q is an inactive waste disposal facility operated by Sauget and Company between 1966 and 1973. The site is presently leased to the Pillsbury Company, which operates a coal-unloading and grain-loading facility at the site. Subsurface conditions in the northern half of Site Q, immediately east of Site R, were previously investigated by USEPA FIT (E & E 1983). The results of this investigation have been summarized in the "Current Situation Report" (provided in Appendix A).

Because of the extensive nature of the FIT investigation in the northern portion of the site, work there for this investigation was limited to the drilling three 43-foot borings and development of these borings into monitoring wells. In the southern portion of the site, five borings were drilled and monitoring wells were installed in each boring. The locations of all borings and the cross-section for this site are shown in Figure 4-15. Soil boring data from the FIT investigation (E & E 1983; B Series borings in Figure 4-15) were used for the cross-section for the northern half of the site. The cross-section G-G' is shown on Figure 4-18.

Data from soil borings in the northern portion of the site indicate that the surface is covered with approximately 4 feet of highly permeable cinders and fly ash that has been used as a cover material for the refuse and fill below. The refuse and fill consists of a mixture of municipal garbage, clay, cinders, and construction debris which is frequently oily and black from staining. The thickness of this layer appears to increase southward, with only 3 feet found in boring B-1 at the north end of the site 17 feet found in B-17. Immediately below the fill are silt and silty sands of the Cahokia Alluvium. These deposits coarsen with depth and at approximately 20 to 28 feet grade into the fine- to medium-grained sands typical of the lower Cahokia and Henry Formation. Borings Q6, Q7, and Q8 were terminated within these sand deposits at approximately 43 feet.

In the southern portion of the site a similar mixture of fill material was found from the surface to depths of 16 to 28 feet. However, the oil and staining observed in the northern fill was not found. In borings Q1, Q2, and Q3, 7 to 13 feet of clay and silt was found immediately below the fill. Below this clay and silt was silty sand. In borings Q4 and Q5, sand was found directly below the fill material, indicating that a portion of the upper Cahokia (clays and silts) may have been excavated prior to disposal of refuse.

The water table was generally encountered in the silty sand deposits below the fill at an average depth of 27 feet. Water levels were found to be below the fill at all boring/well locations during measurement dates, except at borings Q5 and Q8. Water levels at these locations were found at or above the base of the fill on two occasions.

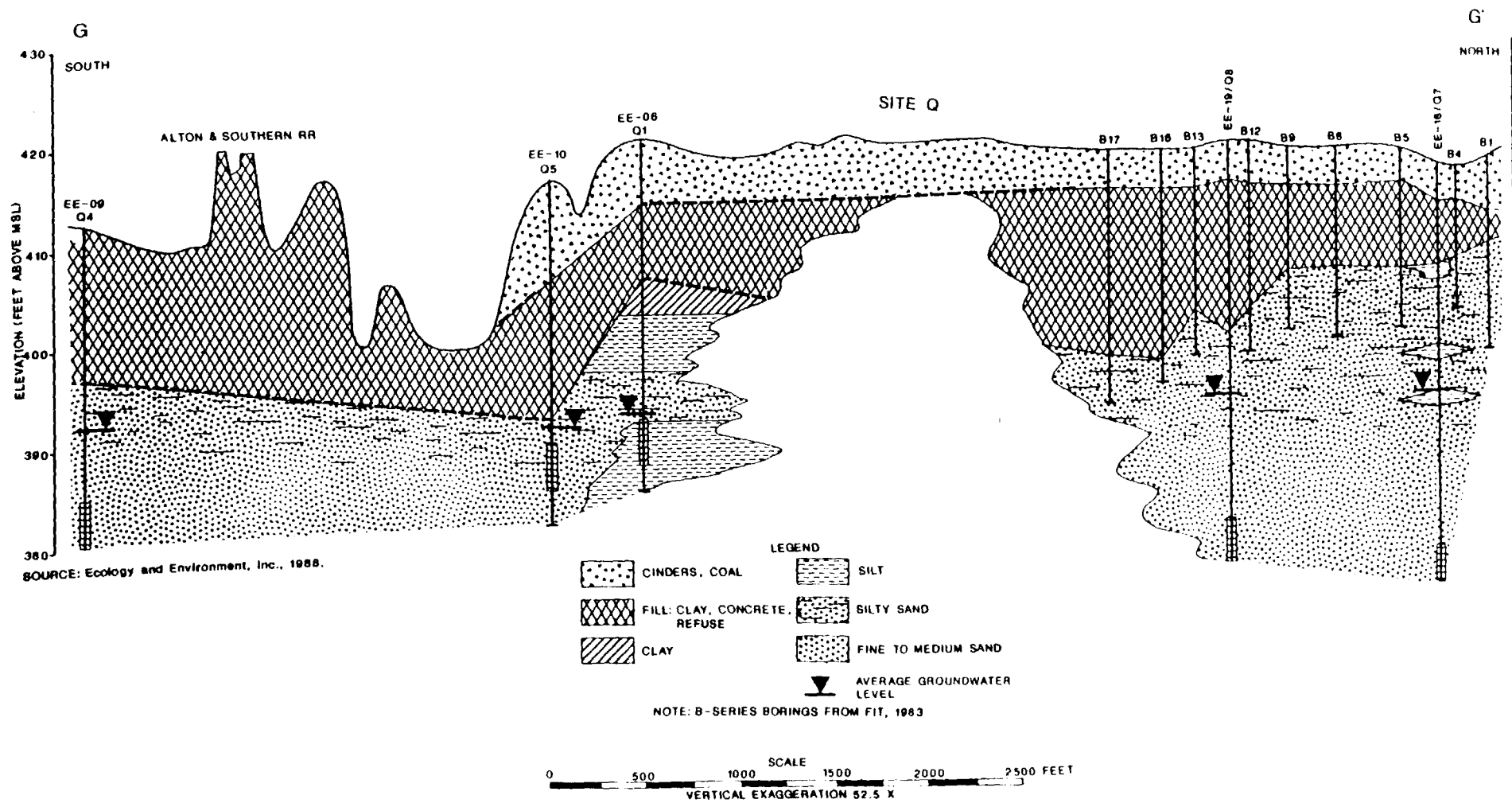


FIGURE 4-1 GENERALIZED GEOLOGIC CROSS SECTION G-G'

The frequency and length of time that portions of the fill may be below the water table appears to be dependent on seasonal fluctuations of the Mississippi River and the response of the water table to these fluctuations. These effects will be discussed in Section 4.1.3.3.

Site R

Site R is the Sauget Toxic Dump, an inactive industrial waste landfill used by the Monsanto for the disposal of liquid wastes. Wastes were pumped from tank trucks and drums into several unlined pits around the site then covered with fly ash, cinders, sandy clay, or gravel. The site has been inactive since 1977. A clay cap, 3 to 6 feet in thickness, has been installed as part of a closure plan for the site.

A great deal of data regarding the subsurface conditions at Site R has previously been developed by IEPA, D'Appolonia (1980), and Geraghty & Miller, (1986) in conjunction with several hydrogeologic investigations conducted at the site. Field work and data collection by Geraghty & Miller for Monsanto continues to this date. Because of the large volume of subsurface information already available for the site, the scope of the present investigation was limited to a review of the available subsurface data, groundwater sampling of selected on-site wells, and water level measurements. Groundwater flow and sample results are discussed in Sections 4.1.3.3 and 4.2.5.2, respectively.

A geologic cross-section of Site R and a small portion of Site Q is presented in Figure 4-19.

In general, borings through Site R indicate that 5 to 20 feet of fill consisting of flyash, cinders, silty clay, sand, miscellaneous debris (e.g., glass, scrap metal), and unidentified saturated waste material and contaminated soil is present below the clay cap (D'Appolonia 1980). Underlying the fill is 15 to 50 feet of Cahokia Alluvium consisting of interbedded silt, clay, and silty sand which grades to a fine- to medium-grained clean sand that coarsens with depth. Deeper borings drilled by Geraghty & Miller indicate that this sand continues down to bedrock, with cobble and boulder layers (encountered at 68 to 126 feet) directly overlying the limestone bedrock.

Groundwater occurs in the alluvium below the fill and fluctuates in depth in response to changing Mississippi River levels. However, water

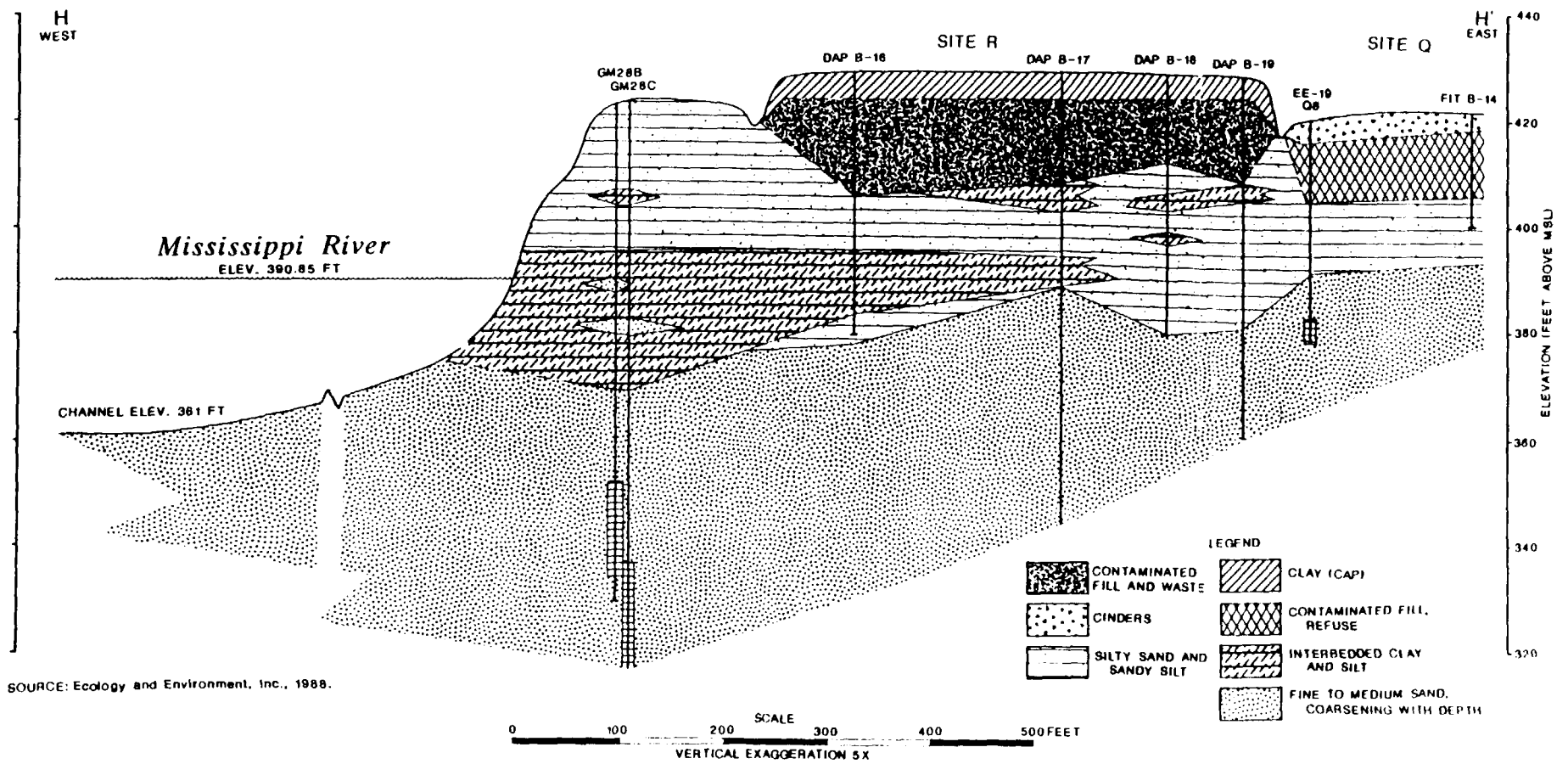


FIGURE 4-19 GENERALIZED GEOLOGIC CROSS SECTION H-H'

levels in the alluvium frequently are found at a higher elevation than inland sites. This is due to the proximity of the site to the river in combination with perched conditions and bank storage effects, as a result of which, when groundwater rises into the alluvium due to a rise in the river levels, it is retained there after the river level drops. Generally, groundwater levels remain below the base of the fill, but may rise to encounter fill materials when river levels exceed the flood stage elevation of 410 MSL (the base of fill is approximately 406 MSL). This situation has occurred at least once in 1973 when the river elevation topped 423 MSL at the Market Street gauge during a period of intensive flooding. Although groundwater levels infrequently encounter the fill, the potential for contaminants to migrate into the groundwater system below the site is indicated by the presence of leachate found to a depth of 60 feet (D'Appolonia 1980) in D'Appolonia boring B-10 (shown in Figure 4-15).

4.1.3 Groundwater Hydrology

4.1.3.1 Hydrogeologic Units

Groundwater exists in both the Cahokia Alluvium and Henry Formation valley fill materials under water table and leaky artesian conditions. Based on the results of this investigation, a review of the available literature, and HRS scoring procedures, these strata have been classified as a single hydrogeologic unit due to the hydrologic connectivity exhibited between strata and the lack of significant confining layers between or within the individual strata. Although the Mississippian bedrock formations immediately below the valley fill also contain groundwater, the relatively lower permeability of these formations and poor water quality with depth generally preclude their use as an important aquifer in the area.

Schicht (1965) and Bergstrom (1956) indicate that the combined effect of variations in grain size (coarsening with depth) and degrees of sorting within the valley fill have caused the hydraulic conductivity (permeability) of the valley fill to increase with depth. These variations in conductivity affect the groundwater flow system and ultimately the transport of contaminants within the study area. To facilitate the hydrogeologic evaluation of the area, the valley fill has been divided

into three zones - shallow, intermediate, and deep - based on relative hydraulic conductivities. These zones have been assigned based on the lithology described in boring logs in the literature and aquifer test results compiled by Schicht (1965). Descriptions of the three zones are as follows:

Shallow Zone. This relatively lower conductivity zone is composed of the coarse alluvial (silty sand) deposits found below the surficial fine-grained silt and clay. The zone extends from the water table to a depth of approximately 45 feet below the ground surface and averages 35 feet in thickness. This depth corresponds to the depth of Cahokia Alluvium in the type section boring described in Section 4.1.2. All monitoring wells installed during this investigation were finished within this zone. Hydraulic conductivities, determined from slug test data from these wells average 96.6 gpd/ft^2 . The natural discharge point for this zone is the Mississippi River.

Intermediate Zone. This zone includes the medium- to coarse-grained sand and gravel deposits of the Henry Formation and extends from 45 to 75 feet below the surface. A depth of 75 feet was chosen for the bottom of this zone based on boring logs presented by Schicht (1965). These borings included Mobil Oil Co. test well 10 (T.2N.,R.10W.Sec. 25) and Monsanto Chemical Corp. well S-2 (T.2N.,R.10W.Sec. 27) as well as ISGS test hole No. 2 (Bergstrom 1956), where coarser deposits such as cobbles, boulders, and coarse gravels are reported below a depth of 75 feet. Schicht also reports the results of aquifer tests utilizing production wells screened within this zone (Ovens Illinois Glass Co. and City of Wood River). Hydraulic conductivity values for this zone were determined to be $2,300 \text{ gpd/ft}^2$ and $2,440 \text{ gpd/ft}^2$, respectively in these tests. Although the hydraulic conductivity determined from the Ovens Illinois Glass Co. well is based on specific capacity data and thus can be only be considered a rough approximation of conductivity, Schicht indicates that the value is reliable due to its similarity to values computed from aquifer tests in comparable strata. These values also compare with a value of $3,300 \text{ gpd/ft}^2$ reported by Geraghty & Miller for aquifer test data from a 65-foot well on the Monsanto property. The

storage coefficient was in the water table range: 0.155 and 0.04 for the City of Wood River and Monsanto test, respectively. The discharge point for this zone is also the Mississippi River. A 1984 hydrographic survey conducted by The U.S. Army Corps of Engineers indicates that the river channel bottom is within the intermediate zone, at a relative depth of 60 feet (361 MSL) below the ground surface at Site R. The channel has a coarse sand and gravel bottom typical of this zone and is relatively sediment free due to the high river velocity.

Deep Zone. This zone includes the coarsest deposits of the Henry Formation, which directly overlie the bedrock. The zone extends from 75 feet to approximately 120 to 130 feet below the surface. Schicht (1965) reported the results of aquifer tests conducted with partially penetrating wells at the Mobil Oil Co. property (1961), east of Site J, and on the Monsanto property (1952). Results from the tests conducted at the Mobil Oil Co. site indicated a hydraulic conductivity of $2,900 \text{ gpd/ft}^2$ and a storage coefficient of 0.100. A storage coefficient of this magnitude signifies water table conditions. Results from the test at Monsanto indicated a hydraulic conductivity of $2,800 \text{ gpd/ft}^2$ and a storage coefficient of 0.082. Reported values of hydraulic conductivity for this zone may be minimum values due to the effect caused by the partial penetration of tested wells. Discharge from this zone is ultimately to the Mississippi River.

4.1.3.2 Historical Groundwater Flow

Prior to development of the Dead Creek area, groundwater levels in the study area were very near the surface elevation of 400 feet above MSL. As a result, ponds, swamps, and poorly drained areas were prevalent. The development of the area led to the construction of levees, drainage ditches, and most importantly, production wells which caused the lowering of groundwater levels and the diversion of groundwater flow toward pumping locations.

The Sauget area has historically been one of the major centers for groundwater withdrawal in the American Bottoms. Withdrawals have largely been from production wells owned by 10 to 17 firms in the area. The Monsanto Chemical Co. property appears to have been at the center of

a large cone of depression which formed as a result of heavy pumpage from Henry Formation sand and gravel deposits. Other facilities that contributed to overall drawdown include Cerro Copper Products Co., Amax Zinc, and Midwest Rubber.

Figure 4-20 shows the estimated groundwater pumpage in the Sauget area for the years 1890 to 1980. The effect of this pumpage on the potentiometric surface is illustrated in Figures 4-21 and 4-22. As shown in Figure 4-20, pumpage in the study area increased significantly from less than 100,000 gpd in 1905 to 31 mgd in 1960 (Ritchey 1984). The change in the groundwater flow pattern during this period can be seen by comparing the 1900, 1951, 1956, and 1960 potentiometric surface maps (Figure 4-21). In the late 1950s and early 1960s, flow was from all directions toward the cone of depression centered on the Monsanto Chemical Co. property, and the resultant gradient within the cone of depression exceeded 30 feet per mile (Schicht 1962). Water levels in the center of the cone were as much as 50 feet lower than prepumping levels. Water levels in Areas 1 and 2 were lowered approximately 30 feet (to 370 MSL) by 1959. This is 27 feet lower than the present average water level of 397 MSL measured at sites in both study areas.

In 1960, a new well field was put in service adjacent to the Mississippi River. The effect of this new field is shown in the November 1961 potentiometric surface map, where a small cone of depression has formed around the Monsanto Chemical Co. Ranney well No. 3, located northwest of Site R. Water levels in other parts of the DCP area, particularly Area 1, recovered somewhat to an elevation of 380 MSL in response to this pumpage.

Groundwater withdrawals peaked in 1962 at 35.5 mgd. From 1962 to 1965, pumpage decreased to 30.4 mgd, partly as a result of water conservation at one industrial facility (Ritchey 1984). The potentiometric surface map for 1966 indicates that groundwater pumpage was concentrated around the Ranney collector near the river. As a result, water levels decreased significantly in Area 2 and only slightly in Area 1. However, water levels in Area 1 remained approximately 22 feet lower than levels measured today.

Groundwater withdrawals continued to decline to 21.2 mgd in 1970 and 12.1 mgd in 1971. These large decreases were due to the closing of

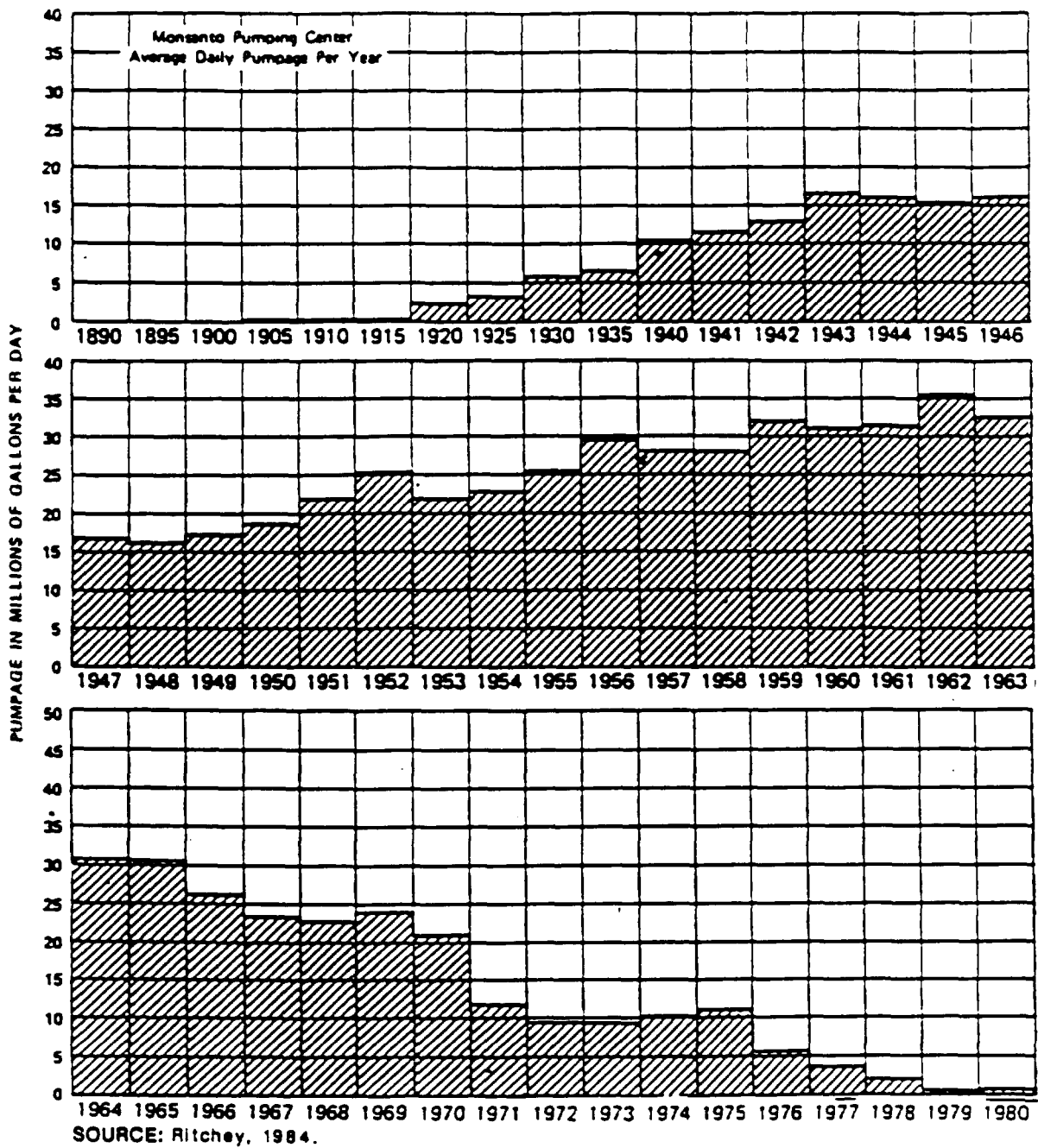
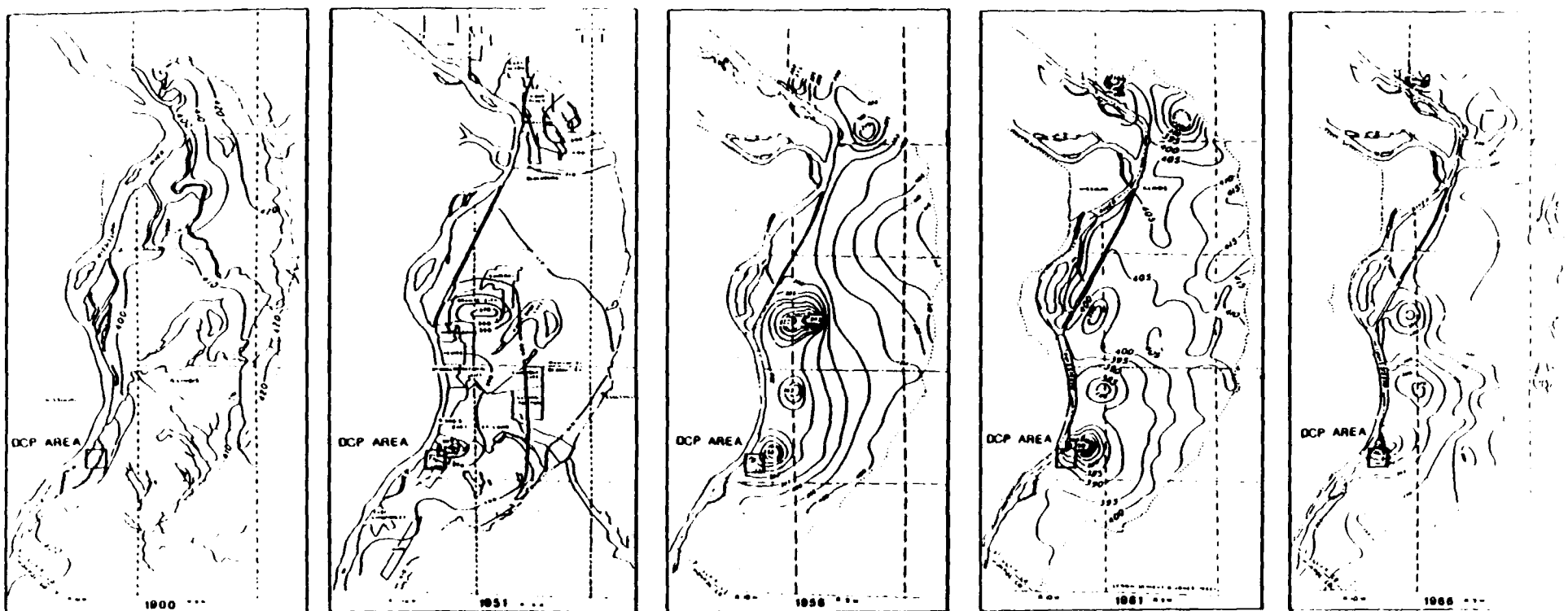


FIGURE 4-20 ESTIMATED PUMPAGE IN THE SAUGET AREA, 1890-1980



SOURCE Illinois State Water Survey Publications

FIGURE 4-21 POTENTIOMETRIC SURFACE MAP FOR
AMERICAN BOTTOMS 1900 THROUGH 1966

two major groundwater using facilities (Ritchey 1984). By 1973, pumpage had ceased at the Monsanto Ranney well No. 3 adjacent to the river. The effect of this change can be seen in the 1973 potentiometric map shown in Figure 4-22. However, a small cone of depression still existed around the Monsanto facility. Water levels in the study areas were at a relatively high elevation in 1973. This phenomenon was probably the result of Mississippi River flooding which occurred earlier that year.

From 1971 to 1977, pumpage dropped to 4.7 mgd. This drop was due to the conversion by some industrial facilities from groundwater pumping to public water supplies from the Mississippi River for their water (Ritchey 1984). A regional deterioration in groundwater quality may have been one reason for this conversion to the use of river water (Geraghty and Miller 1986).

By 1980, pumpage had dropped to 0.5 mgd. Based on ISWS water level data for 1985, this low level of pumpage continues today. The potentiometric surface maps for 1980 and 1985 show no cone of depression in the study area, indicating that by 1980 significant groundwater withdrawals had ceased.

The lowering of the water table as a result of groundwater withdrawals in the study area in the past had changed the natural groundwater flow direction (to the west, toward the river) to radial flow toward pumpage locations at the Monsanto plant and the Monsanto Ranney well No. 3. A significant cone of depression, great enough to draw groundwater from Areas 1 and 2, probably formed in the early 1940s and existed until sometime between 1977 and 1980. During this period, groundwater withdrawals also established hydraulic gradients from the Mississippi River toward the pumping centers. As a result, groundwater levels were below the surface of the river. Thus, appreciable quantities of water were diverted from the river into the aquifer by the process of induced infiltration. Schicht (1965) estimated the induced infiltration recharge volume for the study area to be approximately 18.5 mgd, or approximately 58% of the 31.9 mgd total being withdrawn.

The primary importance of these groundwater withdrawals and subsequent flow diversions for this study is the effect they may have had on contaminant migration from study area sites. Beginning in the early 1940s, heavy pumping from the intermediate and deep zones of the valley

fill deposits at the Monsanto facility produced a deep cone of depression which lowered the water table near the plant from the shallow zone into the intermediate zone and caused water levels in the shallow zone at surrounding properties (i.e., Area 1 sites) to drop to elevations of 370 to 380 feet above MSL. During this early period of pumpage, the pits at Sites G, H, and I were being dug. Figures 4-9 and 4-10 show that these pits were excavated to a depth of 373 to 385 feet above MSL. Excavation to this depth suggests that digging progressed until the water table was encountered. These pits were subsequently filled with liquid and solid wastes. Because the bottoms of these pits were unlined and at or near the water table, surface pumpage in the area would have drawn leachate and contaminants from the shallow zone off-site toward the pumpage location and into the more permeable intermediate and deep zones. Once having migrated to these deeper zones, contaminants would migrate farther and faster than they could in the relatively impermeable shallow zone. Contaminants in Area 1 would not only have been drawn off-site toward the Monsanto Plant, but, based on the groundwater flow direction indicated by the November 1966 potentiometric surface map (see Figure 4-22), may also have been pulled toward the Mississippi River by the cone of depression created by the Ranney collector No. 3 near Site R. The overall result of these flow diversions is an increase in the vertical and areal extent of contamination and the mixing of contaminants across hydrogeologic zones.

Similar contaminant migration patterns are thought to have occurred in Area 2. However, wastes were not disposed at Sites O, Q, and R until the late 1950s and mid-1960s, during which time contaminants would have been drawn off-site exclusively toward the Ranney collector at Site R. Flow would have continued in this direction until 1972 or 1973 when pumpage from the Ranney collector was discontinued. Based on the potentiometric surface maps for 1973 and 1977 (see Figure 4-22), flow may then have been reversed toward a small cone of depression still evident at or near the Monsanto plant.

In the 1970s, when groundwater withdrawals were being phased out and being replaced by pumpage from the river, the water table in Area 1 rose into the waste deposits at Sites G, H, and I. This probably re-

sulted in the increased loading of contaminants to the groundwater system and migration of contaminants off these sites toward the plant.

These pumping effects on contaminant migration continued until approximately 1980, when significant groundwater withdrawal was discontinued and flow to the Mississippi River was resumed. During the period 1940 to 1980, contaminants from both Areas 1 and 2 were contained within the cones of depression produced in the area, preventing the discharge of contaminants to the river. However, with the return of westerly flow patterns in 1980, the potential for contaminant discharge to the river was established. Except for seasonal fluctuations, this flow pattern continues today. Flow patterns and the potential impact of contaminant discharge to the Mississippi River is discussed further in Section 5.

4.1.3.3 Current Groundwater Flow

The following discussion of current groundwater flow patterns is based solely on data collected from monitoring wells screened within the shallow zone of the aquifer (see Section 4.1.3.1). The groundwater investigation concentrated on the following objectives: determining whether an observed release of contaminants to groundwater has occurred at previously uninvestigated sites; determining the sources(s) of observed releases; and filling gaps in data needed for the HRS model. A detailed physical and chemical examination of the intermediate and deep aquifer zones was beyond the scope of this investigation. However, a finite difference groundwater flow model and a contaminant transport model were used to conduct a preliminary evaluation of the intermediate and deep zones. The results of this modeling are presented in Section 5.

Area 1

Groundwater Flow Direction. Current groundwater flow patterns in the shallow zone of Area 1 are based on water level measurements recorded on March 26, May 12, and October 1, 1987. These measurements are provided in Table 4-1. Directions of groundwater flow for each measurement date were developed from this water level data and are shown in Figures 4-23, 4-24, and 4-25, respectively.

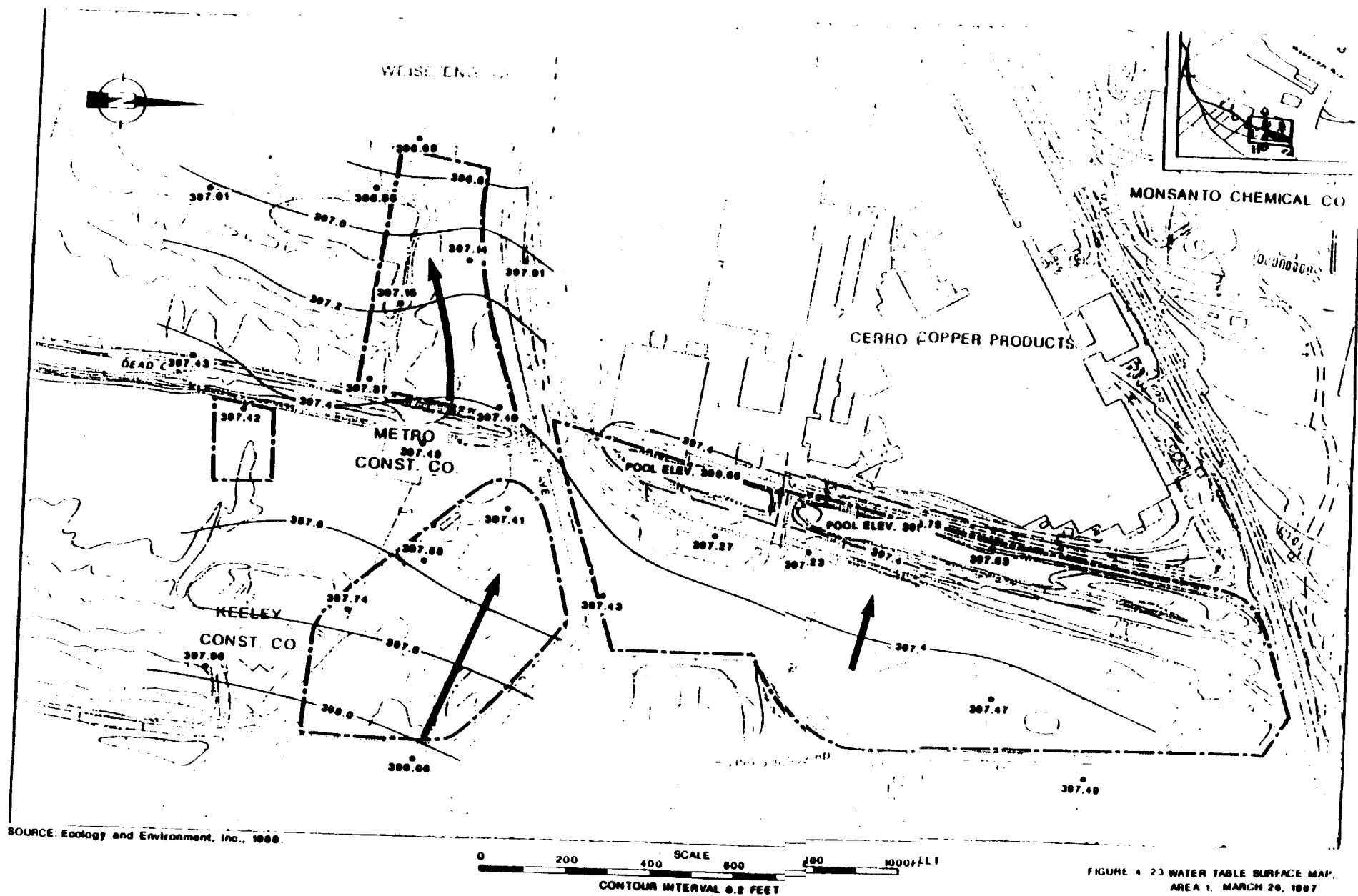
Table 4-1

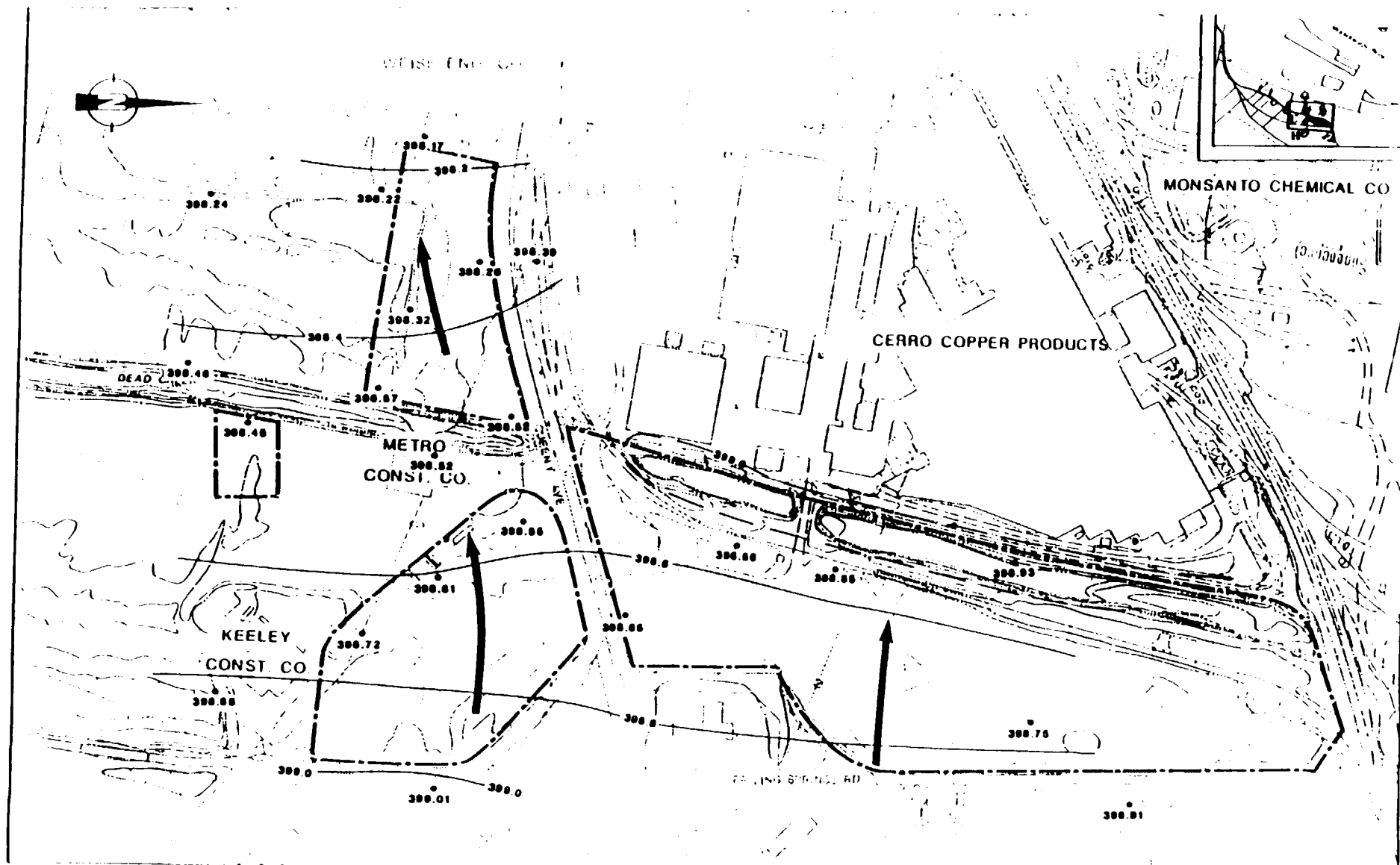
GROUNDWATER ELEVATIONS
AREA 1

Well	Ground Surface Elevation	Elevation at Well Bottom	Groundwater Elevation	Groundwater Elevation	Groundwater Elevation
SITE G					
EE-05	409.06	386.06	396.69	398.17	396.46
EE-11	407.45	384.45	397.04	398.26	396.74
EE-Q101	409.84	387.34	396.86	398.22	396.61
EE-Q102	407.88	386.38	397.37	398.57	397.00
EE-Q103	407.66	386.16	397.43	398.46	397.11
EE-Q104	407.87	383.87	397.01	398.24	396.72
EE-Q106	406.53	383.53	397.40	398.52	397.09
EE-Q107	405.55	377.55	397.15	398.32	396.85
SITE H					
EE-01	406.55	373.55	397.41	398.55	397.11
EE-02	407.66	384.66	397.58	398.61	397.26
EE-03	409.11	377.11	397.74	398.72	397.41
EE-04	411.33	388.33	398.06	399.01	397.64
EE-Q108	406.28	377.28	397.96	398.85	397.53
EE-Q110	407.18	384.68	397.49	398.52	397.12
SITE I					
EE-12	408.64	374.14	397.43	398.65	397.07
EE-13	408.57	381.07	397.47	398.75	397.05
EE-14	409.39	371.39	397.23	398.55	396.89
EE-15	405.08	376.08	397.63	398.93	397.41
EE-16	406.91	373.91	397.27	398.56	396.94
EE-20	410.00	381.00	397.49	398.91	397.14
EE-Q112	406.68	380.68	397.01	398.39	396.78
NORTH POND					
	—	—	399.79	—	399.44
SOUTH POND					
	—	—	399.66	—	399.39
SITE L					
EE-Q109	407.77	385.27	397.42	398.45	397.10

* Pool elevation.

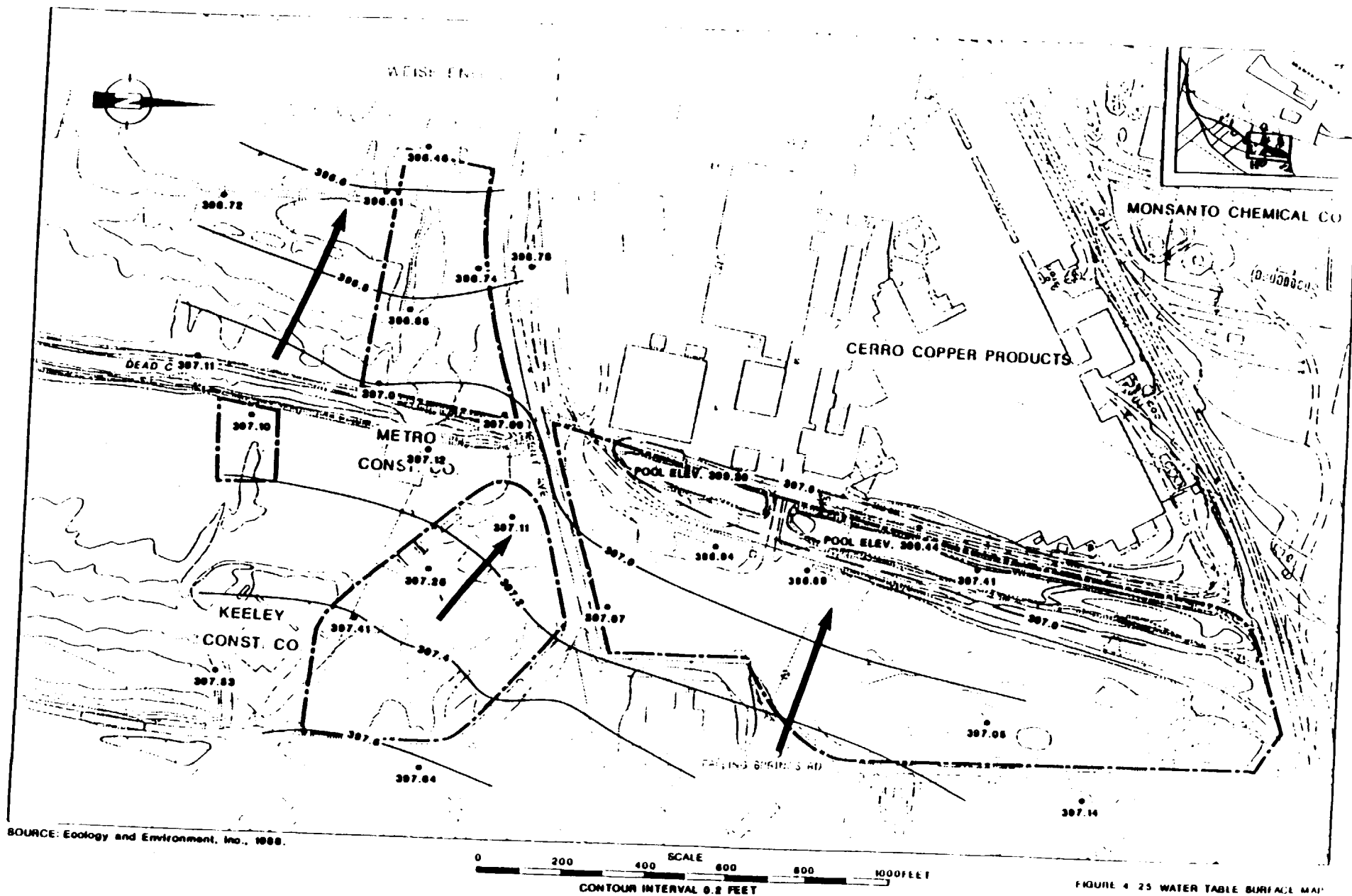
Source: Ecology and Environment, Inc. 1988.





SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 4-24 WATER TABLE SURFACE MAP, AREA 1, MAY 12, 1987



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 4-25 WATER TABLE SURFACE MAP
AREA 1, OCTOBER 1, 1987

The general groundwater flow direction was west to slightly northwest, toward the Mississippi River, on all three measurement dates. Minor fluctuations observed in the flow fields are thought to be the result of variations in local geology. A horizontal hydraulic gradient was calculated between wells EE-04 (east of Site H) and EE-05 (west of Site G) for all three measurement dates. These values are 0.00091 for March 26; 0.00056 for May 12; and 0.00078 for October 1, 1987. The arithmetic average of these values is 0.00075. These results indicate that the slope of the water table in this area is very slight.

The major feature in the flow system is a small groundwater mound which has formed beneath CS-A at Site I. The mound is probably caused by relatively lower permeability sandy silt deposits which have collected in the creek bed and kept water levels in the creek perched approximately 2.5 feet above the surrounding water table. Because these ponds receive storm water and roof drainage from the Cerro facility, a positive head is maintained within the ponds. These fine-grained deposits, however, appear to be permeable enough to allow vertical seepage of surface water, albeit slow, to the water table below. This seepage is evidenced by water levels in well EE-15, located just west of the north pond of CS-A, which are consistently elevated above the surrounding water table because of leakage from the pond. The effects of this mounding on westerly groundwater flow are expected to be minimal.

The hydraulic conditions (i.e., mounding) in the northern half of CS-B would probably be similar to those of CS-A if a positive head was maintained in CS-B. However, because the culvert connecting CS-A to CS-B has been blocked, CS-B receives a much smaller volume of runoff than CS-A. The small amount of storm runoff which CS-B does receive flows to the southern half of CS-B where it ponds above the blocked culvert at Judith Lane. Slow leakage through the creek bed may occur in this area, but this phenomenon has not been investigated. Slow leakage may also occur below water-filled surface depressions in the northern half of CS-B following intense rainfall events. Leakage of this nature was not extensive enough to cause observable mounding effects during this investigation.

Creek Sector B also does not appear to be a consistent discharge point for local groundwater flow. Water levels measured in wells

adjacent to the creek (i.e., EE-G102, EE-G109, and EE-G110) were 1 to 2 feet below the creek bottom on May 12, when water levels were the highest of the three measurement dates. However, should groundwater levels rise above the elevation of the creek bed during months of greater precipitation, contaminated groundwater from Sites G and L, could be discharged to the creek. At the present time, groundwater is in contact with contaminated sediments which extend to a depth of approximately 7 feet (394 MSL) below the creek bed (IEPA 1981).

Hydraulic Conductivity. Hydraulic conductivity values for the fine sand and silty sand deposits of the shallow zone were determined by the analysis of slug test data from eight wells in Area 1. Table 4-2 lists the conductivity values calculated from these tests. The hydraulic conductivity values range from 3.3×10^{-4} ft/sec to 1.5×10^{-5} ft/sec with an arithmetic average of 1.2×10^{-4} ft/sec. Hydraulic conductivity within an order of magnitude of 10^{-4} ft/sec is typical for the unconsolidated clean to silty fine-grained sands encountered in the shallow portion of the aquifer (Freeze and Cherry 1979). This value represents an approximation of the hydraulic conductivity of the shallow zone as a whole. However, because of the grading lithology of deposits in the shallow zone, and because the slug test methodology is only applicable to a small radius of influence, variations in conductivity are to be expected.

Groundwater Velocity. Groundwater velocities were calculated to evaluate the rate of contaminant transport due to groundwater movement in the shallow zone. An approximation of the velocity (V) at which the groundwater moves was calculated using Darcy's equation. Assuming laminar flow in saturated conditions,

$$V = \frac{Ki}{ne}$$

where: K = hydraulic conductivity,
i = horizontal hydraulic gradient, and
ne = effective porosity.

Table 4-2

SHALLOW ZONE HYDRAULIC CONDUCTIVITY VALUES
AREA 1

Site	Test Location	Well Depth (ft)	Aquifer Material	Hydraulic Conductivity, K (ft/sec) (gpd/ft ²)	
G	EE-G101	22.5	Fine sand	4.3×10^{-5}	27.6
G	EE-G102	21.5	Silty sand	4.6×10^{-5}	29.7
H	EE-03	32	Fine-coarse sand	3.3×10^{-4}	211.9
H	EE-04	23	Medium sand	1.7×10^{-4}	110.2
H	EE-G110	22.5	Fine sand	1.7×10^{-4}	112.3
I	EE-13	27.5	Fine sand	4.3×10^{-5}	27.6
I	EE-15	29	Very fine sand	1.5×10^{-5}	9.9
I	EE-G112	26	Fine sand	1.1×10^{-4}	72.1

Average K = 1.2×10^{-4} ft/sec = 75.2 gpd/ft².

Source: Ecology and Environment, Inc. 1988.

A range of velocities for Area 1 was calculated using the average hydraulic conductivity value determined from Area 1 slug tests ($K = 1.2 \times 10^{-4}$ ft/sec) and the horizontal hydraulic gradient values determined for each of the water level measurement dates. An effective porosity value of 0.15 was assumed for the silty sand deposits (Johnson 1967) in each velocity calculation. The results of these calculations are shown in Table 4-3. Velocities ranged from a high of 0.0063 ft/day on March 26, to a low of 0.0039 ft/day on May 12, with an average velocity of 0.0053 ft/day (19.4 ft/yr). These extremely low velocities indicate that the shallow zone alone is not a significant pathway for off-site migration of contaminated groundwater toward the Mississippi River. However, the hydraulic interconnection between the shallow zone and the much more permeable intermediate zone would provide such a pathway. The significance of the relationship between these two zones and the potential effect on contaminant migration is addressed in detail in Section 5.

Area 2

Groundwater Flow Direction. Current groundwater flow patterns in the shallow zone of Area 2 (Sites O, Q, and R) are based on water level measurements recorded on March 25, May 12, and October 1, 1987. These measurements are provided in Table 4-4. Directions of groundwater flow for these measurement dates were developed from this water level data and are shown in Figures 4-26, 4-27, and 4-28, respectively.

Because these sites are close or adjacent to the Mississippi River, water levels measured in monitoring wells in this area fluctuate in response to the rise and fall of the river stage. The degree of fluctuation within any given well due to changes in river stage decreases with distance away from the river. The average change in water levels at Site Q for the three measurement dates was 5.05 feet. This is compared to an average change at Area 2 Site O and Area 1 Site G, which are progressively farther from the river, of 3.88 feet and 1.52 feet, respectively.

The rising and falling river stage also has an effect on groundwater flow directions in Area 2. This is shown in the water table contour map for March 26 (see Figure 4-26), when the water level in the Mississippi River was at higher elevation than groundwater at Site Q.

Table 4-3

GROUNDWATER VELOCITY CALCULATIONS
AREA 1

Date	Hydraulic Cond., K^* (ft/sec)	Gradient, i (ft/ft)	Effective Porosity, n_e	Velocity, v (ft/day)
March 26, 1987	1.2×10^{-4}	0.00091	0.15	0.0063
May 12, 1987	1.2×10^{-4}	0.00056	0.15	0.0039
October 1, 1987	1.2×10^{-4}	0.00078	0.15	0.0054
Average	1.2×10^{-4}	0.00077	0.15	0.0053

* Average value of all Area 1 slug tests.

Source: Ecology and Environment, Inc. 1988.

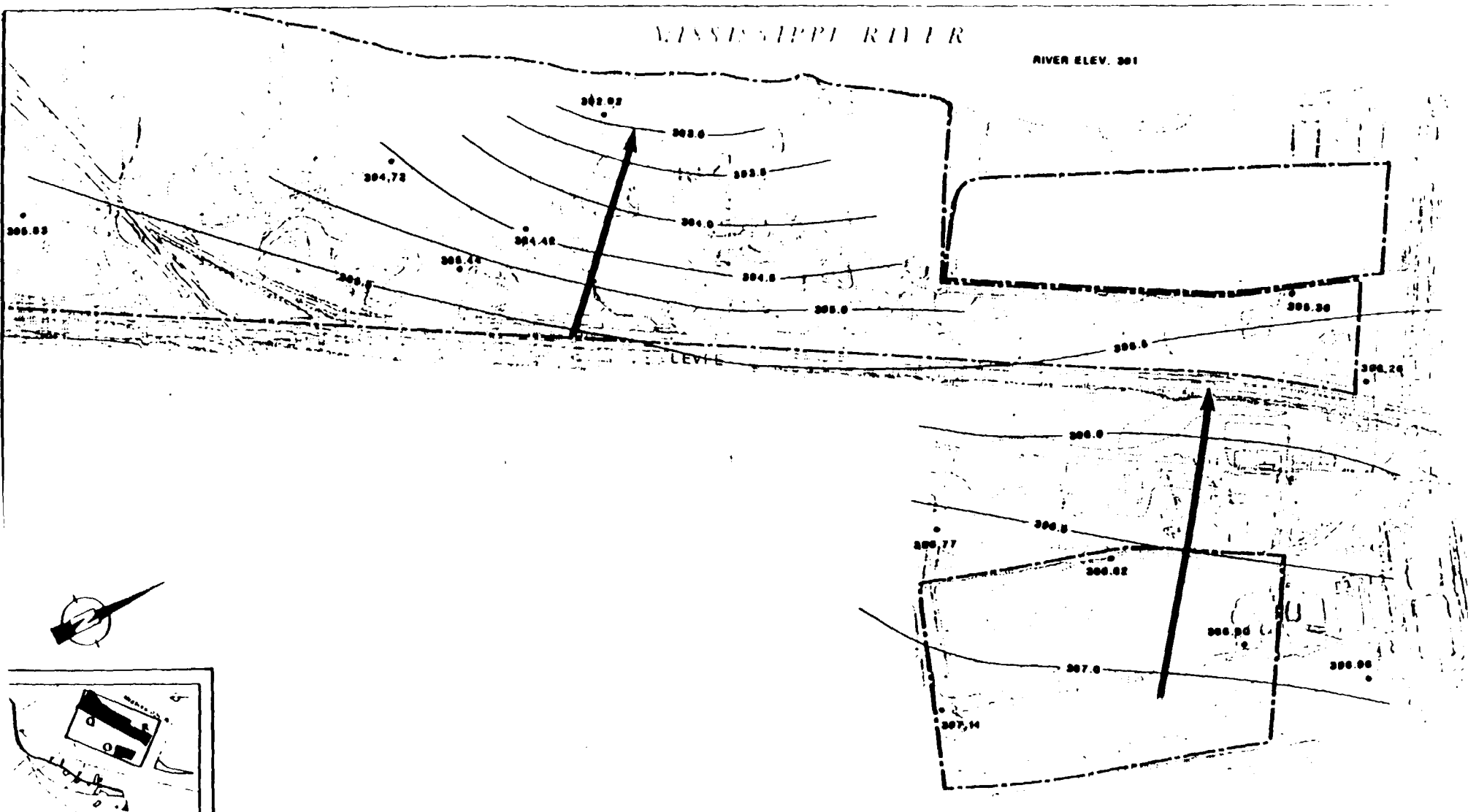
Table 4-4

GROUNDWATER ELEVATIONS
AREA 2

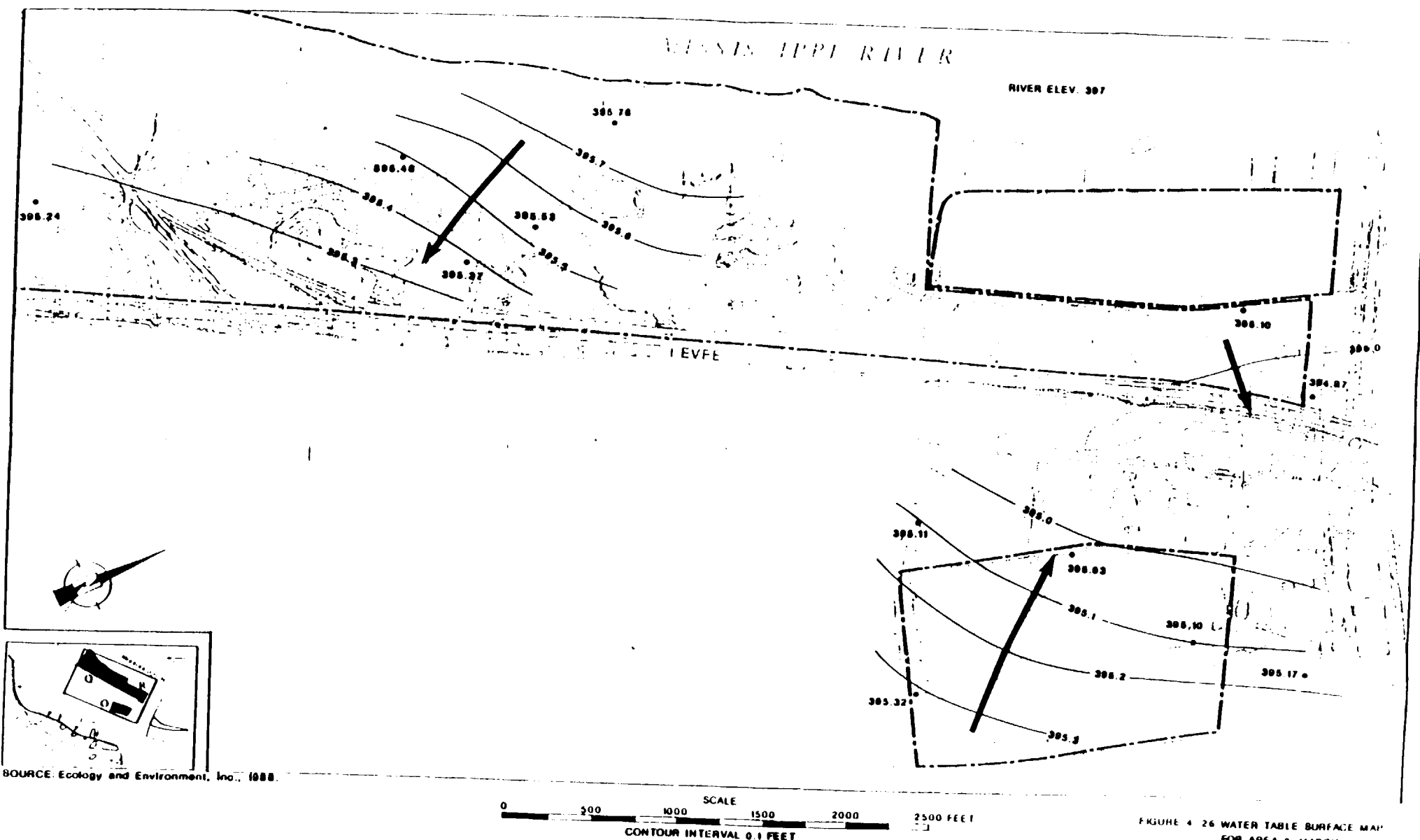
Well	Ground Surface Elevation	Elevation at Well Bottom	Groundwater Elevation 3-26-87	Groundwater Elevation 5-12-87	Groundwater Elevation 10-1-87
SITE O					
EE-21	405.68	377.68	395.17	396.96	393.25
EE-22	414.77	381.77	395.03	396.62	392.50
EE-23	408.46	374.96	395.32	397.14	393.60
EE-24	410.08	377.08	395.10	396.90	393.14
EE-25	408.91	375.91	395.11	396.77	392.51
SITE Q					
EE-06	421.22	388.22	395.53	394.42	dry
EE-07	421.65	383.65	395.48	394.72	389.61
EE-08	419.58	382.00	395.78	392.92	387.49
EE-09	413.38	380.38	395.24	395.83	390.64
EE-10	417.10	384.60	395.37	395.44	390.75
EE-17	422.00	379.00	394.97	396.26	391.34
EE-18	418.20	375.20	395.10	395.36	390.37
EE-19	421.12	378.12	399.27	403.24	391.39
SITE R					
B26A	421.81*	390.81	—	—	396.73
B26B	421.62*	374.62	—	—	388.74
B28A	421.44*	391.44	—	—	397.95
B28B	421.28*	374.28	—	—	389.00
P-1	421.31*	376.31	—	—	388.52
P-7	420.22*	389.22	—	—	398.78
P-11	420.50*	371.50	—	—	388.14

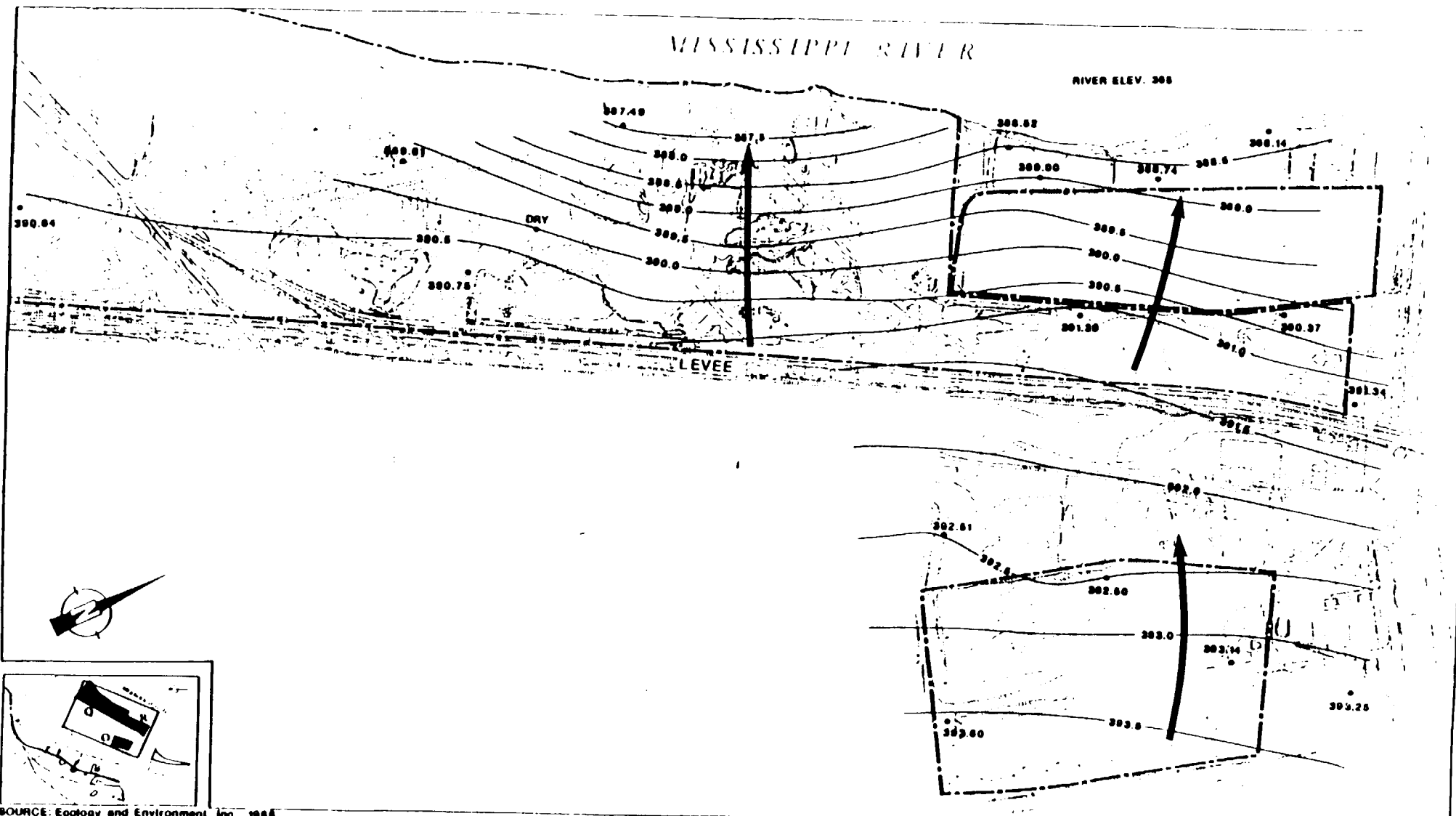
* Geraghty & Miller, 1986.

Source: Ecology and Environment, Inc. 1988.



SOURCE: Ecology and Environment, Inc., 1988.





SOURCE: Ecology and Environment, Inc., 1988.

0 500 1000 1500 2000 2500 FEET
SCALE
CONTOUR INTERVAL 0.5 FEET

FIGURE 4-28 WATER TABLE SURFACE MAP FOR AREA 2, OCTOBER 1, 1987

The high river stage produced a hydraulic gradient from the river to a groundwater divide located between Site O and Site Q, which caused groundwater at Site Q to flow in an east to southeast direction toward the divide, whereas flow at Site O, although also toward the divide, is in a northwesterly direction toward the river. In contrast to this flow pattern, groundwater flow on May 12 (see Figure 4-27) and October 1 (see Figure 4-28), when the river stage was lower than the groundwater level, was west-northwest toward the river at Site O and Site Q.

Flow direction at Site R could not be determined on March 26 and May 12 due to the lack of access to monitoring wells for water levels measurements. However, water levels were measured on October 1 as shown in Table 4-4. Water levels from Site R wells B-26B, B-28B, P-1, and P-11 were used in conjunction with levels from surrounding wells on Sites Q and O to determine groundwater flow directions because of the similar elevations of their screened zones. Other water levels from Site R were from wells (i.e., B-26A, B-28A, and P-7) terminated at a significantly higher elevations and in different geologic conditions than wells B-26B, B-28B, P-1, and P-11. According to the Geraghty & Miller (1986) report for this site, these wells are screened within the fine silty sand, silt, and clay deposits which exist below the landfill. These fine-grained deposits tend to cause local perched water table conditions (i.e., bank storage) following high river stages; therefore, water levels from these wells were not used to evaluate the flow direction on this date. The bank storage effect may be one explanation for the unusually high water levels recorded in well EE-19 on March 26 and May 12. Another reason for these high water levels may be that similar perched or slow drainage conditions (due to the presence of lower permeability wastes or fine-grained materials) may also exist at some locations in Site Q.

In Figure 4-29, water table elevations for wells EE-10, EE-18, and EE-19 are correlated with daily Mississippi River stage data measured by the U.S. Army Corps of Engineers at the Market Street gauge. When groundwater levels are below river stage, as on March 26, flow is in an easterly direction away from the river (see Figure 4-26). When groundwater levels are above river stage, as on May 12 and October 1, groundwater flow is westerly toward the river (see Figures 4-27 and 4-28).

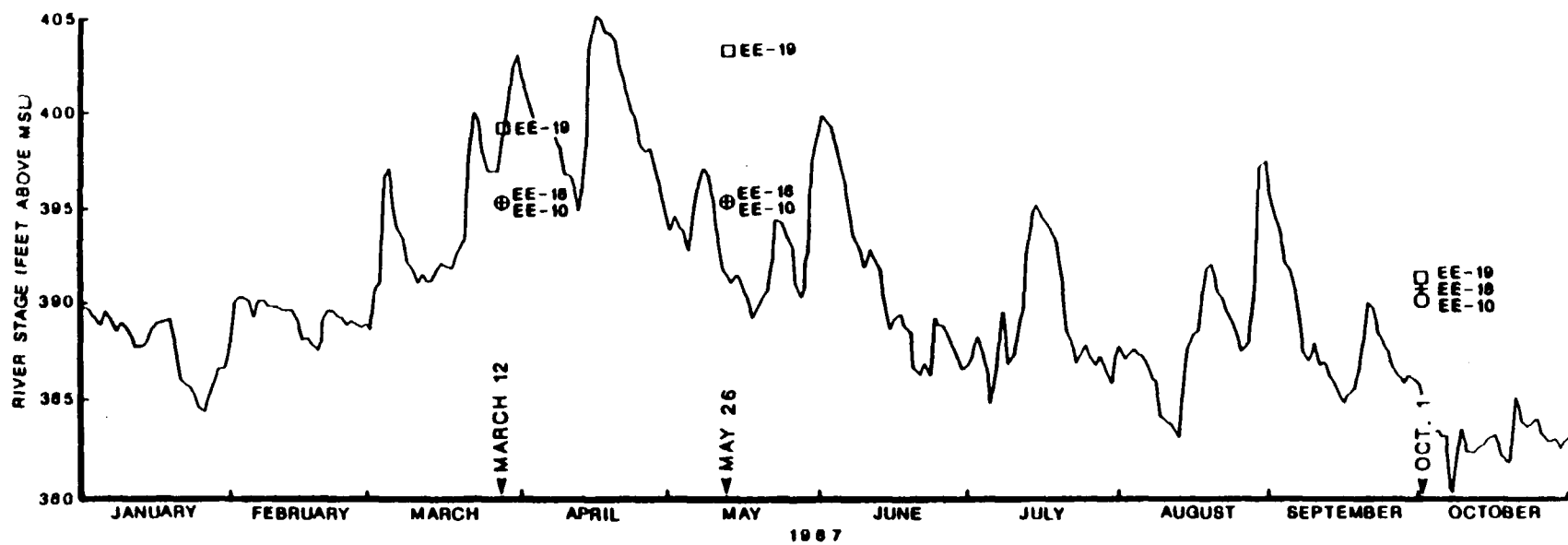


FIGURE 4-29 MISSISSIPPI RIVER STAGE, JANUARY THROUGH OCTOBER, 1987

The anomalous levels for well EE-19 are also shown, along with the corresponding river stage peaks which produced these conditions. The similarity of water level elevations in all three wells on October 1 indicates that a river stage greater than 397.5 (recorded on August 30, 1987) is required to produce perched water table effects in well EE-19.

The eastward extent of flow reversal in Area 2 is dependent on the stage to which the Mississippi River rises. The location of the groundwater divide generally delineates the eastward extent of this effect. On March 26, 1987, the divide occurred between Sites O and Q in response to a river elevation of 400 MSL recorded approximately 6 days earlier. Geraghty & Miller (1986) reported a groundwater divide located just west of Illinois Route 3 in response to a river stage of approximately 412 MSL on November 21, 1985. This indicates that flow reversal in these shallow zone may be expected to approach Area 1 when river elevations exceed the official flood stage level of 410 MSL. Horizontal hydraulic gradients for each water level measurement date were also calculated for Sites O and Q. At Site O, the average gradient was 0.0008. At Site Q, the average gradient for flow toward the river was 0.0030. On March 26, when groundwater flow was away from the river, the hydraulic gradient at Site Q was 0.0004. Because of the responsiveness of Site Q wells to changes in river stage, the gradient is highest at this site during periods of low river stage (e.g., 0.0034 on October 1). Subsequently, as river stage rises, gradients toward the river decrease until river stage exceeds the elevation of the groundwater. At this point, gradients reverse away from the river and begin to increase until river stage begins to fall. This effect was also observed at Site O. The fluctuation of gradients is less at this site than at Site Q due to the greater distance of Site O from the river.

Hydraulic Conductivity. Values were determined from slug test analysis of seven Area 2 wells. Results are provided in Table 4-5. At Site O conductivity values ranged from 2.1×10^{-5} ft/sec to 5.2×10^{-4} ft/sec, with an arithmetic average of 2.0×10^{-4} ft/sec. At Site Q values ranged from 3.1×10^{-5} ft/sec to 3.6×10^{-4} ft/sec, with an arithmetic average of 1.7×10^{-4} ft/sec. These values are within an

Table 4-5

SHALLOW ZONE HYDRAULIC CONDUCTIVITY VALUES
AREA 2

Site	Test Location	Well Depth (ft)	Aquifer Material	Hydraulic Conductivity, K	
				(ft/sec)	(gpd/ft ²)
0	EE-21	28	Medium sand	7.5×10^{-5}	48.7
0	EE-24	33	Fine-medium sand	2.1×10^{-5}	13.8
0	EE-25	33	Fine-medium sand	5.2×10^{-4}	339.1
Average				2.1×10^{-4}	133.9
Q	EE-06	33	Fine sand and silt	7.2×10^{-5}	46.6
Q	EE-17	43	Medium sand	3.1×10^{-5}	20.1
Q	EE-08	38	Fine-medium sand	3.6×10^{-4}	233.1
Q	EE-09	33	Fine-medium sand	2.3×10^{-4}	146.2
Average				1.7×10^{-4}	111.5

Source: Ecology and Environment, Inc. 1988.

order of magnitude of the values determined for Area 1, indicating that similar geologic materials were monitored in both areas.

Groundwater Velocity. Groundwater velocities within the shallow zone at two Area 2 sites (Sites O and Q) were calculated using the procedures discussed for Area 1. Results are provided in Table 4-6. At Site O, the average velocity of flow toward the river, based on the available gradients, was 0.0968 ft/day. This rate is approximately 18 times greater than the average velocity calculated at Area 1 for flow toward the river in the shallow zone. At Site Q, the average velocity for May 12 and October 1, when flow was observed toward the river, was 0.2938 ft/day. This rate is approximately 55 times greater than velocities for the same dates in Area 1. On March 26 when flow was away from the river at Site Q, the groundwater velocity was 0.0382 ft/day. Groundwater velocities in Area 2 are expected to vary from these averages as gradients fluctuate in response to the river stage.

4.1.4 Infiltration Tests

The results of infiltration testing using a double-ring infiltrometer are reported in Table 4-7. Infiltration rates were calculated by the method described in ASTM standard D3385-75. Because of the many variables involved in this test method (described in Section 3.6.6), the limited number of tests conducted, and the expected variation of resultant infiltration rates from location to location at any given site, the rates reported in Table 4-7 are not necessarily representative of infiltration rates for the respective sites. More realistically, these values represent a range over which the infiltration rate may vary at any given site, depending on the soil type, moisture content, and soil structure. In areas where sandy materials predominate near the surface, infiltration rates may be similar to values reported for Site G (10.1 and 12.0 in/hr). In areas where a high percentage of silty clays are found, infiltration rates similar to that of Site O (1.5×10^{-2} in/hr) may be expected. Infiltration rates for sites covered with heterogeneous fill materials (Sites G, H, J, K, L, P and Q) may exhibit a large range of values. At Site O and Site R, where silty clay has been

Table 4-6

GROUNDWATER VELOCITY CALCULATIONS
AREA 2

Date	Hydraulic Cond., K (ft/sec)	Gradient, i (ft/ft)	Effective Porosity, n _e	Velocity, V (ft/day)
SITE O				
March 26, 1987	2.1×10^{-4}	0.0003	0.15	0.0363
May 12, 1987	2.1×10^{-4}	0.0007	0.15	0.0847
October 1, 1987	2.1×10^{-4}	0.0013	0.15	0.1572
Average	2.1×10^{-4}	0.0008	0.15	0.0968
SITE Q				
March 26, 1987	1.7×10^{-4}	0.0004*	0.15	0.0382*
May 12, 1987	1.7×10^{-4}	0.0026	0.15	0.2482
October 1, 1987	1.7×10^{-4}	0.0034	0.15	0.3246
Average**	1.7×10^{-4}	0.0030**	0.15	0.2938**

* Flow gradient is away from river.

** Average for May 12 and October 1 when flow gradient is toward the river.

Source: Ecology and Environment, Inc. 1988.

Table 4-7

RESULTS OF INFILTRATION TESTING

Test Number	Date	Length of Test (hrs)	Volume Infiltrated During Test (ml)	Infiltration Velocity (Rate), V	
				in/hr	cm/hr
<u>Site G</u>					
1-G	7-20-87	0.33	11,124	10.1	96.1
2-G	7-20-87	0.50	11,124	12.0	30.5
<u>Site H</u>					
1-H	6-30-87	0.50	133.4	1.5×10^{-1}	3.7×10^{-1}
2-H	6-30-87	0.75	103.2	7.5×10^{-2}	1.9×10^{-1}
<u>Site O</u>					
1-O	7-14-87	1.3	85.9	1.5×10^{-2}	3.9×10^{-2}
<u>Site Q</u>					
1-Q	7-20-87	1.5	579.8	2.1×10^{-1}	5.3×10^{-1}

Source: Ecology and Environment, Inc. 1988.

used as cover material over large portions of the sites, infiltration rates are expected to be at the low end of the observed range.

The primary utility of infiltration rates in this investigation is for an evaluation of the efficiency of surface soils to inhibit the infiltration of precipitation to the subsurface. For example, there is a greater potential for precipitation to leach contaminants from surface or subsurface soils in areas with high infiltration rates than in areas with lower rates, where a large part of the precipitation may be lost to overland flow or discharged by the process of evapotranspiration. Precipitation that reaches the subsurface in high infiltration rate areas may eventually recharge the aquifer. Should contamination be present above the water table, contaminants could then be transported to the aquifer. Areas with higher infiltration rates may also manifest a relatively greater rise in the water table following a precipitation event. This could result in the aquifer coming in contact with wastes normally isolated above the water table.

Within the study area, the occurrence of high infiltration rates and the subsequent potential for contaminant leaching to the subsurface may be significant at the following sites.

Site Q Contaminated refuse was found above the water table (E & E 1983). The potential for high infiltration rates exists due to the use of cinders and fly ash as cover material.

Site P Analysis of subsurface soil sample P1-53 indicates that contamination is present above the water table. Cinders and fly ash were also used for cover material.

Site L Site history indicates that wastes were discharged to soils above the water table. Soils above the water table were also observed to be visibly stained during subsurface drilling. Permeable cinders and construction debris were used to fill the old impoundment.

Site J The surface of the site is covered with foundry sand and slag. Leaching of heavy metals is possible in this permeable material.

Site K Significant contamination was found in samples of fill material (K1-08 and K2-25) above the water table. The potential exists for high infiltration rates to occur in the heterogeneous fill material at the site.

Other sites at which high infiltration rates may exist include Sites G, H, and I. Although large volumes of waste are already in contact with the aquifer at these sites, high infiltration rates could result in additional contaminant loading to the aquifer from wastes and contaminated fill material found above the water table.

At Site O and Site R, it is assumed that the silty clay cover material will limit the infiltration rate relative to other sites. At Site N, the water table is located 1 to 2 feet below the surface. Organic contaminants were found in each of the two borings at Site N (N1-05 and N2-06). However, because of the high water table, laboratory results may be representative of groundwater quality rather than soil quality. The significance of high infiltration rates at this site is presently unknown.

Conversely, the occurrence of low infiltration rate areas could be particularly significant at Site G, where surficial waste materials and contaminated soils could be carried off-site by overland flow during precipitation events.

In summary, although the infiltration test data is limited and somewhat inconclusive due to the many variables involved, the data provide a preliminary evaluation of the leaching and run-off potential at the DCP sites. Additional site-specific data would be necessary for a more precise evaluation.

4.2 CHEMICAL RESULTS AND DISCUSSIONS

Chemical contaminant investigations consisted of analysis of subsurface soil gas, surface water, sediments, surface soils, subsurface soils, groundwater, and air samples collected at various sites and creek

sectors. The procedures and locations of the sample collection were described in Section 3. With the exception of subsurface soil gas samples, all samples were analyzed for organic and inorganic data packages which included all HSL compounds, plus metals and cyanide (see Table 3-2). With the exception of dioxin analysis samples, which were analyzed by Envirodyne Engineers, Inc., St. Louis, Missouri, analyses of samples were conducted at E & E Analytical Services Center (ASC) using procedures defined in E & E's approved Dead Creek Project Quality Assurance Plan, dated May 1986. Procedures were slightly modified at a January 30, 1987 meeting attended by Ron Turpin of QAS at IEPA; Jeff Larson, Federal Site Project Manager at IEPA; Mike Miller, E & E Project Manager; Andy Clifton, E & E ASC Manager; and Caryn Wojtowicz, E & E GC Manager to compensate for the extremely high contaminant concentrations which were being encountered in samples from the DCP sites. Complete analytical results for all samples are tabulated and presented in Appendix D.

Discussion of analytical results for each investigation are usually broken down into the following categories: volatile organics, semi-volatiles, pesticides and PCBs, and inorganics. In general, the organic compounds analyzed for are not naturally occurring and their presence indicates contamination due to human activities. Laboratory analyses included many inorganic parameters which are ubiquitous and have little environmental or health significance. Accordingly, although these parameters are included in the Appendix D results, they are not discussed in the report. The inorganic parameters of interest were antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, silver, vanadium, zinc, and cyanide.

The analytical data are sometimes qualified. Qualified data are indicated by a "J," an "E," or a "B." The "J" qualification indicates estimated concentrations less than or equal to detection limits. For all "J"-qualified data, the analyte has been detected and is present. The "E" qualification indicates that the concentration is estimated because the amount detected in the sample exceeds the calibrated range for that compound. The "E"-qualified values are probable underestimates of true concentrations. The "B" qualification indicates that the analyte has been found in the laboratory blank as well as the sample, indicating

possible or probable laboratory or field contamination. Compounds that are frequent laboratory or field contaminants are: acetone, 2-butanone, methylene chloride, and all phthalates. Because these laboratory/field contaminants were frequently detected but were determined on most instances not to be indications of environmental contamination, most detected concentrations of these chemicals were ignored. In a limited number of samples, the detected values were determined to be actual indicators of environmental contamination, and in these cases the detected concentrations are discussed.

4.2.1 Soil Gas Survey

Ninety-six soil gas survey locations were tested at Sites G, H, I, J, K, L, M, and N, and Creek Sectors A, B, and C. The soil gas survey was conducted to provide semi-quantitative data concerning the levels of contamination at the project sites listed above. The data was used to aid in the placement of soil borings and monitoring wells rather than as an analytical method to determine contaminant boundaries.

4.2.1.1 Results

The results are presented in Table 4-8 and Figures 4-30, 4-31, 4-32, 4-33, and 4-34.

Site G. Eleven locations were tested for volatile soil gases at Site G. Soil gas test results for Site G provided only limited indications of the presence of subsurface volatile organics. The highest soil gas measurement at Site G was detected at SG-12 which measured greater than 100 mg/L. Two other soil gas samples at Site G were substantially above background: SG-11 (100 mg/L) and SG-50 (18 mg/L).

Site H. Twelve locations were tested for volatile soil gases at Site H. Soil gas results for Site H identified six locations (SG-13, SG-15, SG-18, SG-21, SG-22, and SG-23) where volatile organic soil gases were detected at greater than 1,000 mg/L and one location (SG-14) at greater than 100 mg/L.

Table 4-8

SOIL GAS MONITORING RESULTS

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-1	L	250 feet south of Metro, 3 feet east of Dead Creek (D.C.) Fence	3	0
SG-2	L	300 feet south of Metro, 2 feet east of D.C. Fence Adjacent to IEPA G109	5	7
SG-3	L	305 feet south of Metro, 84 feet east of D.C. Fence	5	0
SG-4	L	275 feet south of Metro, 94 feet east of D.C. Fence	3	>1000
SG-5	L	275 feet south of Metro, 158 feet east of D.C. Fence	3 4	68 >1000
SG-6	L	250 feet south of Metro, 158 feet east of D.C. Fence	1.7	340
SG-7	L	305 feet south of Metro, 155 feet east of D.C. Fence	3	6

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-8	L	275 feet south of Metro, 185 feet east of D.C. Fence	2.5	30
SG-9	L	275 feet south of Metro, 210 feet east of D.C. Fence	2.5	>1000
SG-10	L	305 feet south of Metro, 210 feet east of D.C. Fence	3 5	0 0
SG-11	G	120 feet south of Queeny Ave., 80 feet west of D.C. Fence	3	100
SG-12	G	26 feet south of Queeny Ave., 70 feet west of NW cornerpost D.C. Fence	3	>100
SG-47	G	Center of Grid G-1	3	0
SG-48	G	Center of Grid D-2	3	0
SG-49	G	Center of Grid C-4	3	1
SG-50	G	Center of Grid G-4	3	18
SG-51	G	Center of Grid J-2	3	2

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-52	G	Center of Grid B-2	3	0
SG-92	G	Center of Grid B-3	3	4.2
SG-93	G	Center of Grid A-4	3	0.6
SG-94	G	Center of Grid E-4	2.5	2.2
SG-13	H	80 feet south of Queens Ave.,	3	280
		150 feet east of Metro drive	5	>1000
SG-14	H	80 feet south of Queens Ave.,	1.8	>100
		250 feet east of Metro drive		
SG-15	H	180 feet south of Queens Ave.,	3	>1000
		150 feet east of Metro drive		
SG-16	H	180 feet south of Queens Ave.,	3	5.2
		250 feet east of Metro drive		
SG-17	H	360 feet south of Queens Ave.,	2.5	3.8
		250 feet east of Metro drive		
SG-18	H	360 feet south of Queens Ave.,	3	>1000
		350 feet east of Metro drive	4.5	>1000

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-19	H	75 feet south of fire hydrant, 80 feet west of Falling Springs Road	3	2.2
SG-20	H	25 feet north of fire hydrant, 80 feet west of Falling Springs Road	3	0.2
SG-21	H	180 feet north of SG-18, 146 feet west of SG-20	3	>1000
SG-22	H	100 feet north of SG-21	2.2	>1000
SG-23	H	85 feet southeast of SG-14 in line with SG-22	3	>1000
SG-24	H	360 feet south of Queeny Ave., 140 feet east of Metro drive	2.8	2.0
SG-25	CS-C	40 feet south of Judith Lane, 45 feet west of center of Dead Creek	3 5.2	0 0.5
SG-26	CS-C	200 feet south of Judith Lane, 10 feet west of center of Dead Creek	1	1.5
SG-27	CS-C	100 feet north of Cahokia St., 10 feet west of center of Dead Creek	1	0

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-28	CS-B	20 feet south of north end of D.C. fence, Center of creek bed	1 2.5	2.8 >100
SG-43	CS-B	East bank of creek, 75 feet north of Site M	1	0
SG-44	CS-B	250 feet north of SG-43	1	0
SG-45	CS-B	East bank of creek, Adjacent to south side Metro building	1	0
SG-46	CS-B	West bank of creek, 25 feet north of SG-45	open hole	280
SG-95	CS-B	Behind Metro building	1.5	1.5
SG-96	CS-B	50 feet north of SG-95	2	1
SG-29	N	Center of pit	1.5	180
SG-30	N	Southeast corner of pit	3	>1000
SG-31	N	40 feet east of pit	2.5	0
SG-32	N	Northwest corner of pit	2	38

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-33	N	Southwest corner of pit	3	0
SG-34	N	East side of pit on east-west center line	2.2	680
SG-35	N	Northeast corner of pit	2.5	7
SG-36	N	35 feet east of SG-30	3.2	>1000
SG-37	M/CS-B	North side of cut-through, Dead Creek side	1	1
SG-38	M	West-central site area	2.5	0
SG-39	M	Northwest corner of site area	1.2	0
SG-40	M	North-central site area	1.2	18
SG-41	M	Northeast corner of site	1	0
SG-42	M	East side of site, 25 feet from northeast corner	1	16
SG-53	I/CS-A	50 feet north of access road, West side of pond	1	1.6

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-54	I/CS-A	50 feet south of north line, West side of pond	1	1.2
SG-55	I/CS-A	East center of south pond	1	0.6
SG-56	I/CS-A	North point of vegetated area east of R.R. tracks, adjacent to north pond	3 5	0.8 1
SG-57	I/CS-A	East point of vegetated area east of R.R. tracks, adjacent to north pond	3	1
SG-58	I/CS-A	South point of vegetated area east of R.R. tracks, adjacent to north pond	3 5	0.8 1.2
SG-59	I/CS-A	West point of vegetated area, 15 feet east of R.R. tracks - north pond	3	1.1
SG-60	I	Along south fence, 20 feet east of center line of south pond	3	92
SG-61	I	100 feet east of SG-60	3	>1000
SG-62	I	100 feet east of SG-61	1.5	>1000
SG-63	I	100 feet east of SG-62	open hole	>1000

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-68	I	15 feet east of well G112	3	0
SG-69	I	East side of R.R. tracks, near southern extent of bend in road to well G112	2.8	2.8
SG-70	I	30 feet east side of R.R. tracks, near bend in road in scrap area	1	2.4
SG-71	I	15 feet west of R.R. tracks near north- central portion of south pond	3	>1000
SG-72	I	15 feet west of R.R. tracks near south end of south pond	3	>1000
SG-73	I	East side of site, behind city hall, along fence	3	0
SG-74	I	20 feet west of R.R. tracks, near center of north pond	3	3.6
SG-75	I	10 feet west of R.R. tracks, near south end of north pond	3	>1000
SG-64	K	Northwest corner of site	3	>1000

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-65	K	Southwest corner of site	3	>1000
SG-66	K	Southeast corner of site	3	>800
SG-67	K	Northeast corner of site	2	2
SG-76	K	North central half of site	3	1
SG-77	K	South central site area, 15 feet west of power tower	3	0.4
SG-90	K	Center of west half of site	3	>1000
SG-91	K	Center of east half of site	3	2.5
SG-78	J	150 feet north of southeast corner	3	1
SG-79	J	North central surface disposal area	3	>1000
SG-80	J	West central -50 feet east of R.R. tracks	2	>100
SG-81	J	125 feet west of gate, 25 feet north of fence	1.2	0.8
SG-82	J	West central 50 feet south of SG-80	3	8

Table 4-8 (Cont.)

Soil Gas Location Number	Site Designation	Location of Sample	Depth (ft)	Concentration Above Background (mg/L)
SG-83	J	West side of northeast pond	3	0.6
SG-84	J	Southwest corner of southeast pond, 15 feet south of pond	2.5	4
SG-85	J	South-central embankment of southeast pit	2	1
SG-86	J	25 feet east of central part of southeast pit	2.8	0.8
SG-87	J	Northwest embankment of southeast pit	2	1
SG-88	J	Midway on a line between SG-79 and SG-80	3	>1000
SG-89	J	Approximately 100 feet north of SG-79, 50 feet west of power pole line	2	65

Source: Ecology and Environment, Inc. 1988.

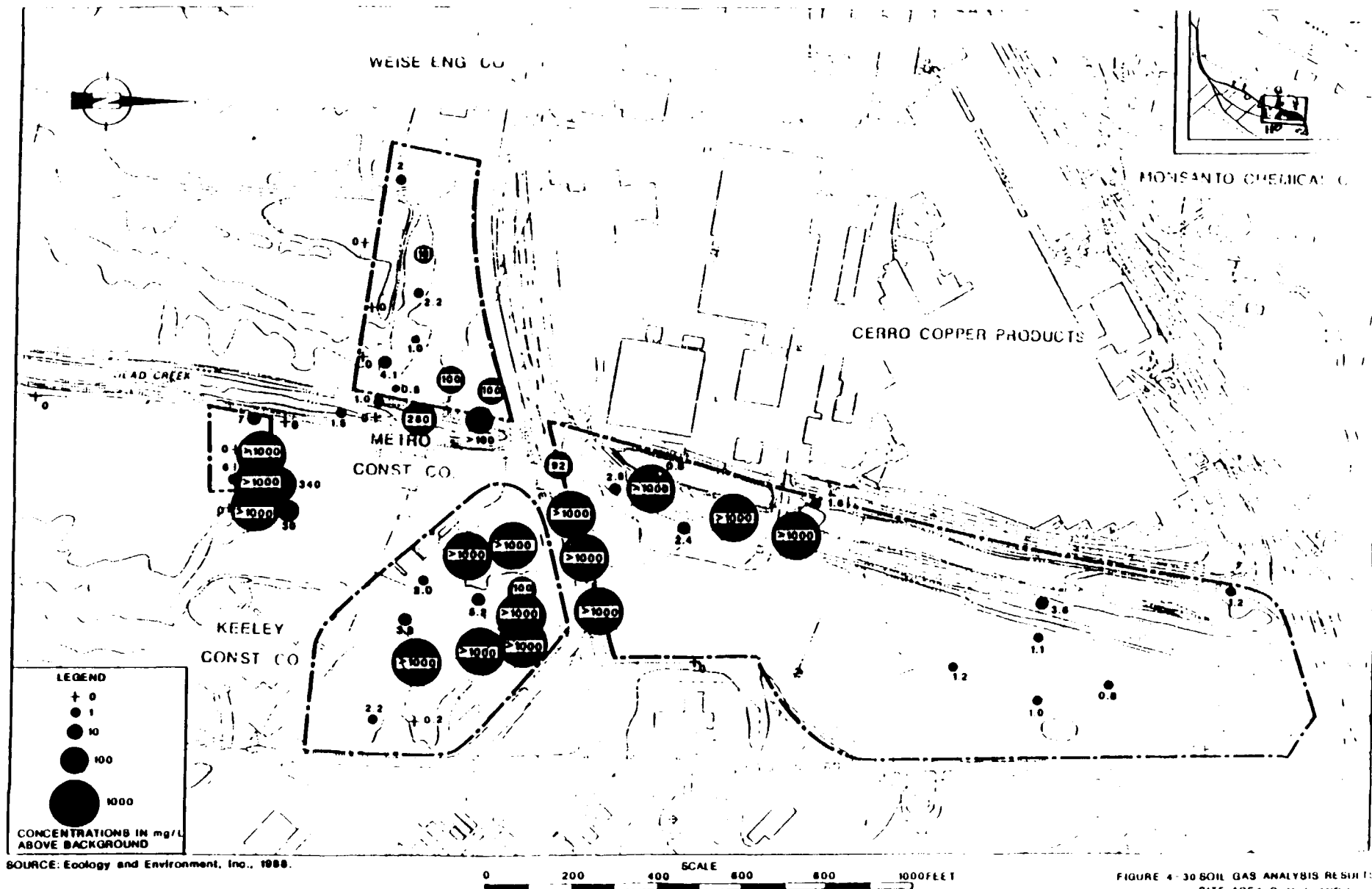


FIGURE 4-30 SOIL GAS ANALYSIS RESULTS FROM SITE AREA Q, H, I, AND J

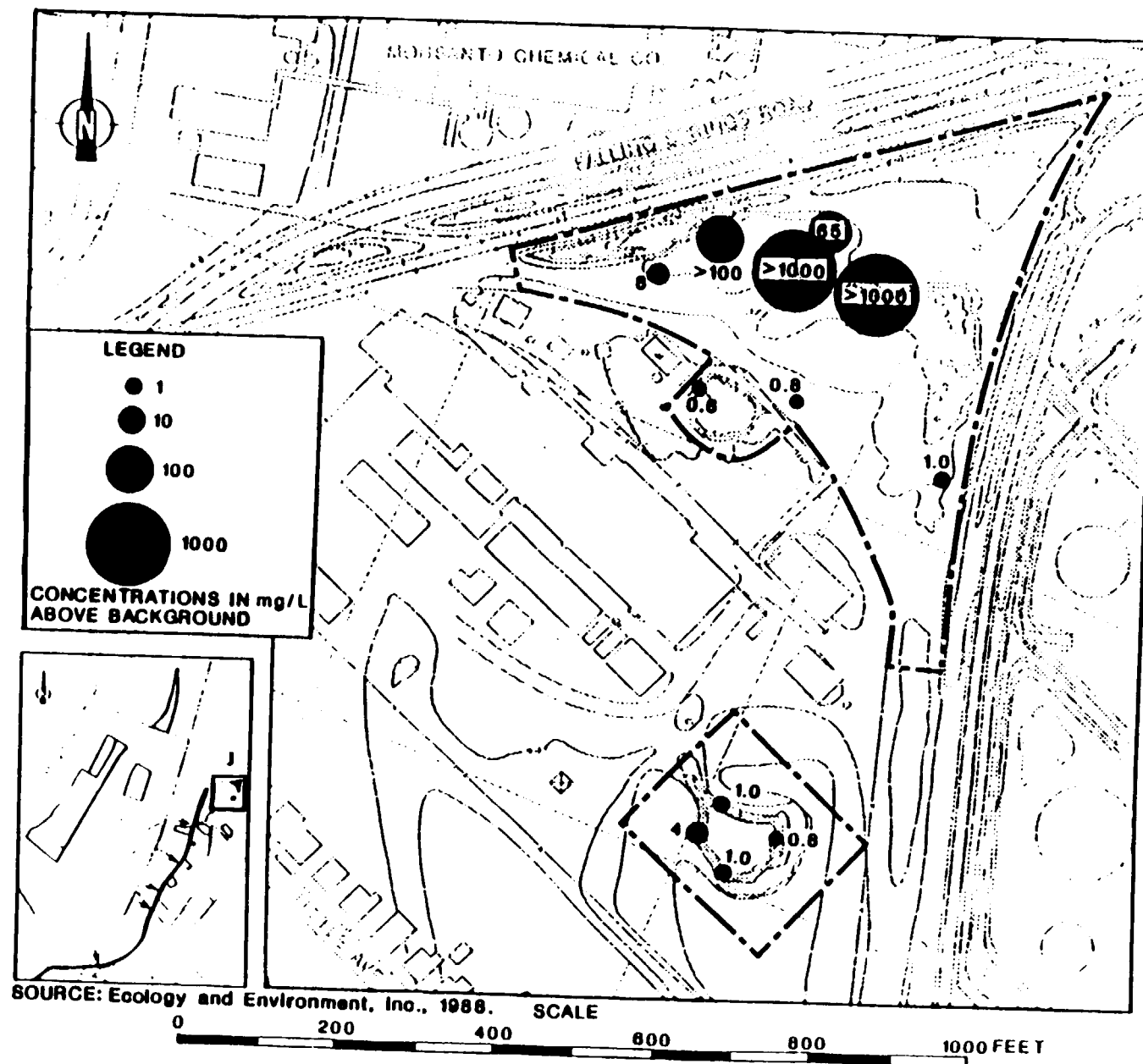
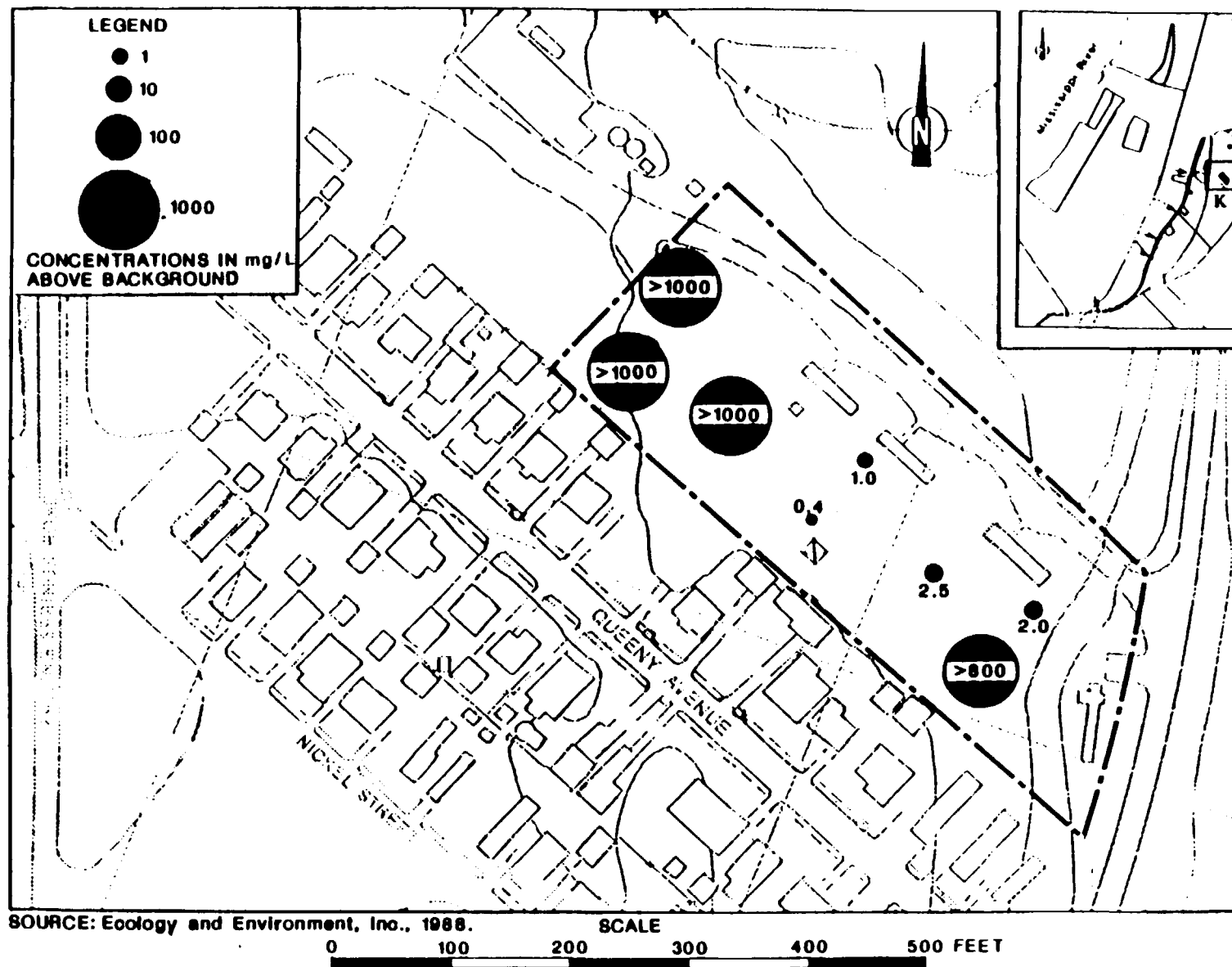
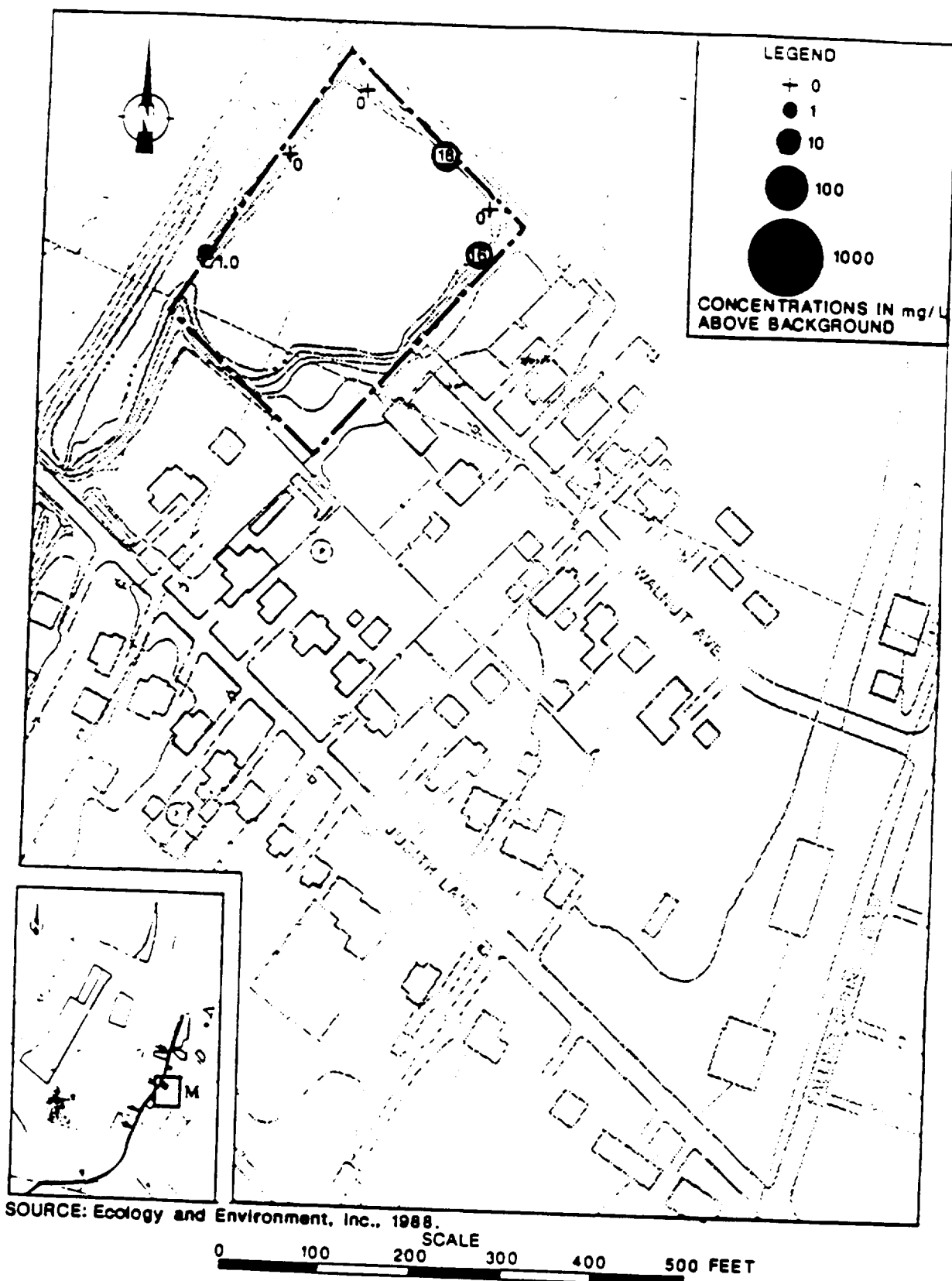


FIGURE 4-31 SOIL GAS ANALYSIS RESULTS FOR SITE J





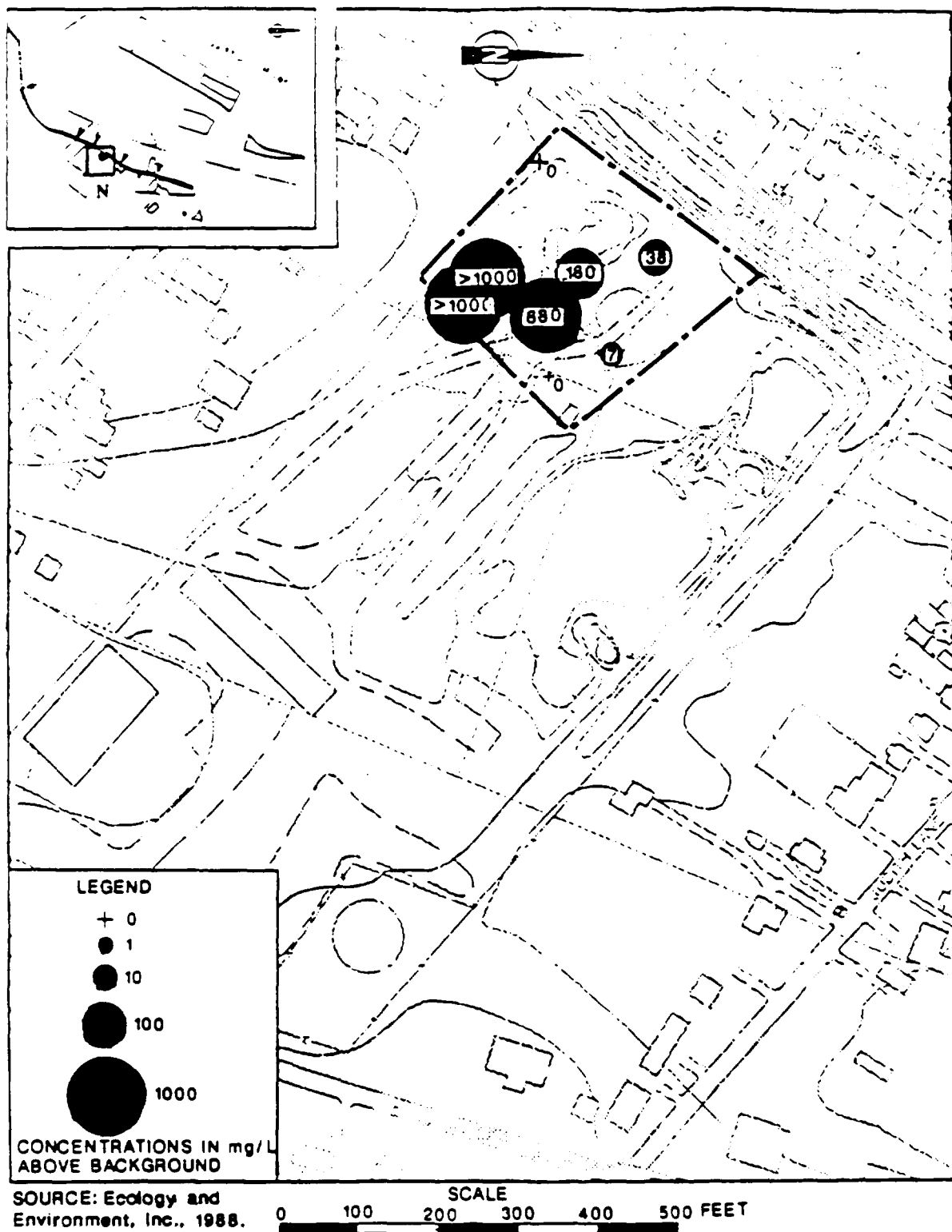


FIGURE 4-34 SOIL GAS ANALYSIS RESULTS FOR SITE N

Site I and Creek Sector A. Nineteen locations were tested for volatile soil gases in CS-A and Site I. Results from these locations identified six locations (SG-61, SG-62, SG-63, SG-71, SG-72, and SG-75) where volatile organic soil gases were detected at greater than 1,000 mg/L, and one location (SG-60) substantially above background at 92 mg/L.

Site L. Ten locations were tested for volatile soil gases at Site L. At five locations (SG-4, SG-5, SG-6, SG-8, and SG-9), volatile organic soil gases were substantially above background (>1,000 mg/L, >1,000 mg/L, 340 mg/L, 30 mg/L, and > 1,000 mg/L, respectively). These soil gas locations were spread across the northern half of Site L.

Creek Sector B. Seven locations were tested for volatile organic soil gases in CS-B. Soil gas test results for CS-B identified two locations (SG-28 and SG-46) where volatile organic soil gases were substantially above background (>100 mg/L and 280 mg/L, respectively). These test locations were in the northern 300 feet of the creek sector.

Site J. Twelve locations were tested for volatile soil gases at Site J. At four locations (SG-79, SG-80, SG-88, and SG-89), volatile organic soil gases were substantially above background (>1,000 mg/L, >100 mg/L, > 1,000 mg/L, and 65 mg/L, respectively). These four locations are in the northwest portion of Site J.

Site K. Eight locations were tested for volatile soil gases at Site K. At four locations (SG-64, SG-65, SG-66, and SG-90), volatile organic soil gases were substantially above background (>1,000 mg/L, >1,000 mg/L, >800 mg/L, and >1,000 mg/L, respectively). These locations are in the western half and the southeastern corner of the site.

Site M. Six locations were tested for volatile organic soil gases at Site M. Only relatively low levels were identified. In the north central portion of the site and on the northeast side of the site, 18 mg/L and 16 mg/L of volatile organics were detected at SG-40 and SG-42, respectively.

Site N. Eight locations were tested for volatile organic soil gases at Site N. At five locations (SG-29, SG-30, SG-32, SG-34, and SG-36), volatile soil gases were substantially above background (180 mg/L, >1,000 mg/L, 38 mg/L, 680 mg/L, and >1,000 mg/L, respectively). The highest concentrations were detected in the eastern and southeastern portions of the site.

Creek Sector C. Three locations were tested for volatile organic soil gases in CS-C. The highest detected concentration was 1.5 mg/L at SG-26.

4.2.1.2 Discussion

The highest levels of soil gases at the DCP site were at Site H and Site I/CS-A. At both sites, six locations had concentrations greater than 1,000 mg/L. At Site H, the locations of high readings encircled the excavation identified in historical aerial photographs which is now filled. At Site I/CS-A, the locations of high readings were in the southern and southwestern portions of the site. The locations in the southern portion cut across the excavation identified in historical aerial photographs which is now filled; the locations in the southwestern portion correspond to the western edge of that excavation.

Sites J, K, L, and N also had locations with concentrations greater than 1,000 mg/L. The highest concentrations in Site J were along the northwestern site boundary. At Site K, the highest concentrations were along the western site boundary. At Site L, the highest detected concentrations extended across the site, east to west. At Site N, the highest concentrations were detected in the southeastern portion of the site.

Sites G and M and CS-B had substantially elevated soil gas readings, although all detected concentrations were below 1,000 mg/L. CS-C had no readings above 1.5 mg/L.

The results indicated the possibility of groundwater contamination at Sites J, K, and N, where no monitoring wells exist and no groundwater quality data exists. These soil gas test results provided a basis for locating the soil borings and monitoring wells.

4.2.2 Surface Water and Sediment Sampling

Surface water and sediment samples were collected from Creek Sectors A, B, C, and D, and from the pond on Site M.

4.2.2.1 Results

Dead Creek surface water and sediment sampling results are presented in Figures 4-35, 4-36, and Table 4-9. Complete results are in Appendix D. Organic and inorganic constituents were detected in the sediments of Creek Sectors A, B, C, and D, and in the pond at Site M. Contaminant groups detected included volatile organics, semivolatiles, pesticides and PCBs, and organics. Organic contamination in surface water was limited to Creek Sectors A and B. Inorganic contamination was present in Creek Sectors A, B, C, and D, and Site M.

Volatile Organics. Analysis of the 11 samples of surface water revealed volatile organics in two samples, both from CS-A. Eight volatiles were detected; the highest concentration was for 1,1,1-trichloroethane (0.041 mg/L) at SW-13 in CS-A.

Analysis of the 21 samples of Dead Creek sediments revealed volatile organics in two samples. Six volatiles were detected in CS-B sample SD-14; the highest detected concentration was for chlorobenzene at 5.2 mg/kg.

Semivolatile Organics. Analysis of the 11 surface water field samples revealed semivolatile organics in two samples. Two semivolatiles were detected, with the highest concentration being 0.009J mg/L of 2-nitroaniline in CS-B sample SW-04. Sample SW-12 contained 4-chloroaniline at 0.003J mg/L.

Analyses of the 21 sediment samples revealed semivolatile organics in all 21 samples. Twenty-nine different semivolatiles were detected. The highest concentration was 220 mg/kg of 1,4-dichlorobenzene at SD-14, from CS-B. Benzo(a)pyrene, the most frequently detected semivolatile, was detected in 13 samples. Table 4-9 lists the most frequently detected semivolatiles.

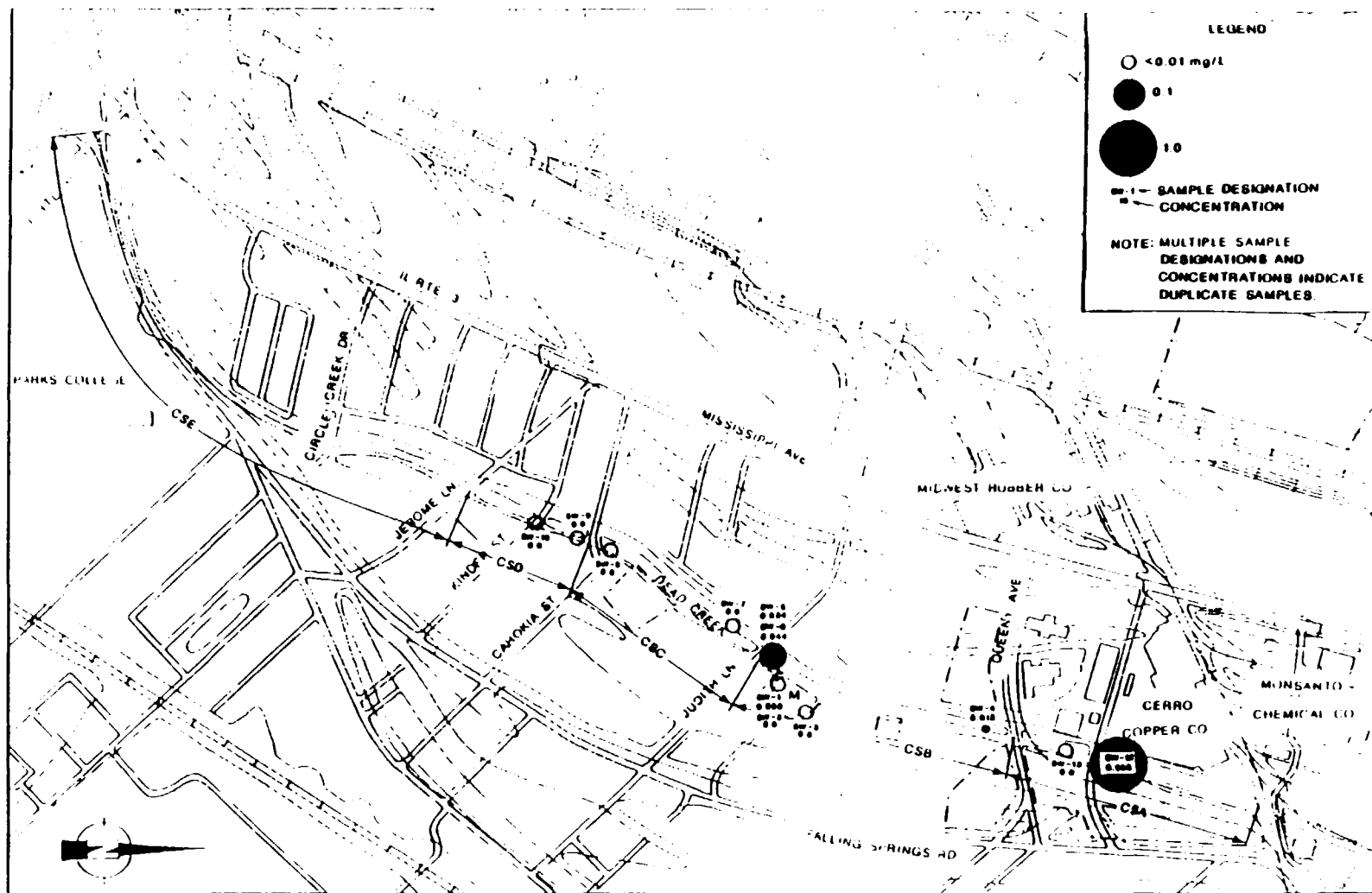
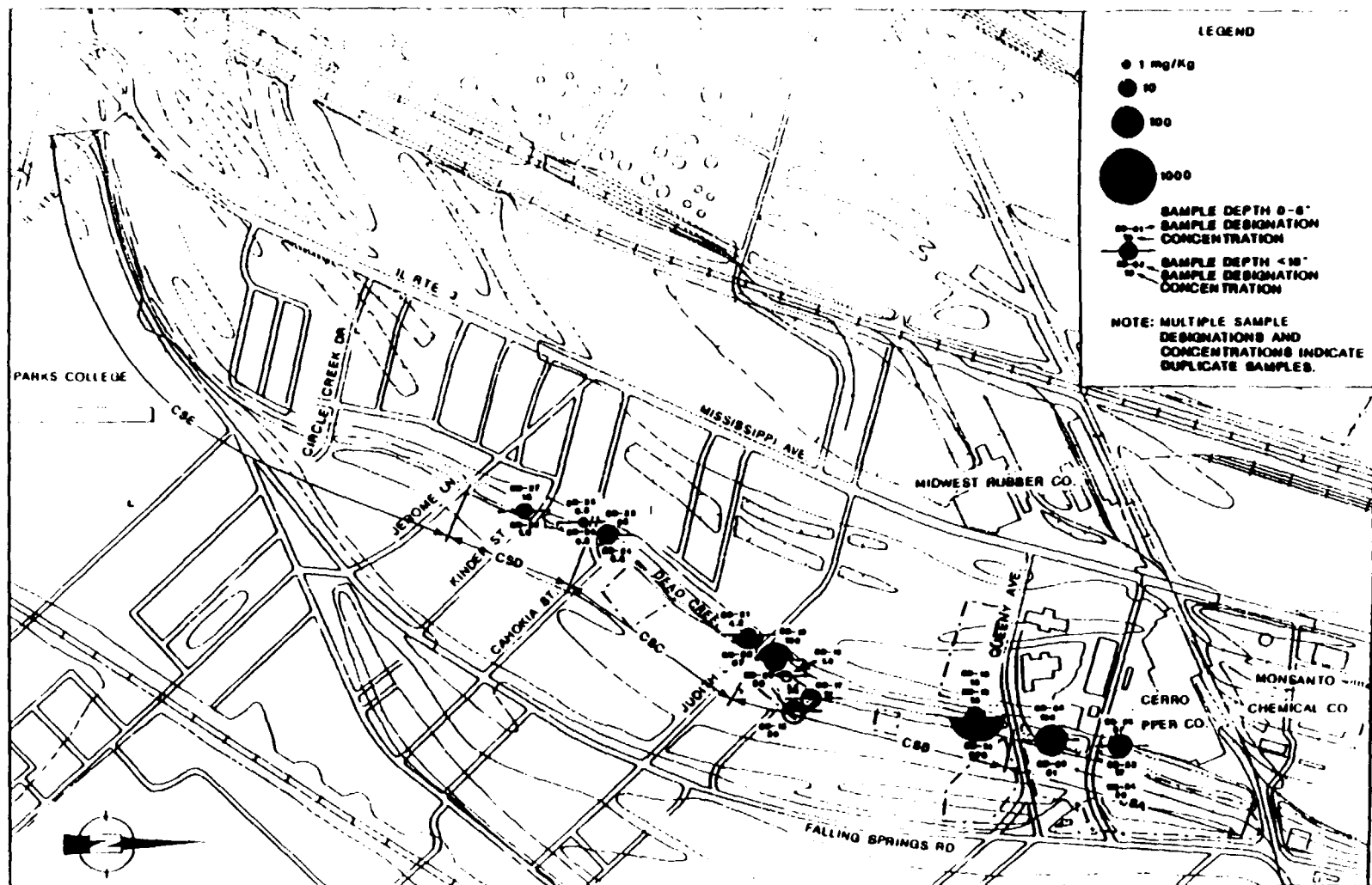


FIGURE 4-35 TOTAL ORGANIC CONCENTRATIONS IN SURFACE WATER SAMPLES AT IRAP



SOURCE: Ecology and Environment, Inc., 1988

FIGURE 4-36 TOTAL ORGANIC CONCENTRATIONS IN SEDIMENT SAMPLES AT D.P.

Table 4-9

SUMMARY OF ORGANIC CONTAMINATION OF SEDIMENT SAMPLES

Chemical Name ^a	Number of Times Detected ^a	Highest Concentrations Detected (mg/kg)	Sample Containing Highest Concentration	Location of Highest Concentration
<u>Volatile Organics</u>				
chlorobenzene	2	5.2	SD-14	CS-B
<u>Semivolatile Organics</u>				
1,4-dichlorobenzene	7	220	SD-14	CS-B
1,2-dichlorobenzene	3	17	SD-14	CS-B
1,2,4-trichlorobenzene	9	5.4	SD-14	CS-B
naphthalene	7	9.4	SD-14	CS-B
methylnaphthalene	3	8.4	SD-14	CS-B
1,3-dichlorobenzene	3	0.55	SD-36	CS-A
pentachlorophenol	3	0.94J	SD-19	CS-B
pyrene	10	13J	SD-14	CS-B
benzo(a)pyrene	13	4.5	SD-22	CS-C
benzo(a)anthracene	5	3.3	SD-22	CS-C
dibenzo(a,h)anthracene	10	4	SD-22	CS-C
benzo(b)fluoranthene	10	7.5	SD-22	CS-C
<u>Pesticides/PCBs</u>				
Aroclor 1242	1	20	SD-16	Site M
Aroclor 1248	8	480	SD-14	CS-B
Aroclor 1254	14	141	SD-19	CS-B
Aroclor 1260	14	66	SD-14	CS-B
endrin	1	0.58	SD-25	CS-D

^a A total of 21 sediment samples were collected. The numbers listed indicate the number of samples, of the total of 21, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Pesticides and PCBs. Analysis of the 11 surface water samples revealed Aroclor 1260 in three samples. All three were from CS-B. The highest concentration detected was 0.044 mg/L in SW-06. No other pesticides or PCBs were detected in surface water samples.

Analysis of the 21 sediment samples revealed PCBs in 18 samples. The highest PCB concentration was in SD-14, from CS-B, where Aroclor 1248 was detected at a concentration of 480 mg/kg. Aroclor 1254 and Aroclor 1260 were the most frequently detected PCBs (14 times each). One pesticide was detected in sediments. Endrin was detected at a concentration of 0.58 mg/kg in CS-D sample SD-25. Table 4-9 lists the pesticides and PCBs detected in sediments.

Dioxin. Analysis of seven sediment samples from six locations were analyzed for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). No 2,3,7,8-TCDD was detected.

Inorganics. Analysis of the 11 surface water samples revealed elevated concentrations of the heavy metals cadmium, mercury, copper, barium, arsenic, chromium, and lead. The highest concentrations were detected in Creek Sectors A and B. The highest detected heavy metal concentration was 17,900 mg/L of copper in CS-B sample SW-06.

Analysis of the 21 sediment samples revealed elevated concentrations of cadmium, mercury, copper, barium, arsenic, chromium, and lead. With the exception of cadmium, the highest concentrations were detected in Creek Sectors A and B. The highest detected heavy metal concentration was 17,300 mg/L of barium in CS-B, sample SD-19.

4.2.2.2 Discussion

Examination of the results of the surface water and sediment sampling reveals contamination in all four creek sectors sampled (A, B, C, and D) and in the pond on Site M. Creek Sectors A and B had the most highly contaminated surface water samples. CS-A had the greatest number of contaminants (11), while CS-B had the highest single contaminant concentration of 0.044 mg/L of Aroclor 1260. Because Creek Sectors A and B are effectively impoundments, the results were as expected, i.e., higher concentrations than in Creek Sectors C and D, where the natural

flow is unimpeded and drainage is occurring. No organic contamination of surface water was detected at Site M.

Similarly, the most highly contaminated sediment samples were those from Creek Sectors A and B. The general absence of volatiles in sediments may have been due primarily to the medium concentration methodology utilized by the laboratory on all but one of the sediment samples, rather than the absence of contamination. When volatiles in one sediment sample (SD-14) were analyzed by low-concentration methods, six volatiles were detected. Sample holding time limits prevented re-analysis of the samples whose volatiles were analyzed by medium-concentration methods. The semivolatile, pesticide/PCB, and inorganic contamination in sediments was, as expected, substantially higher than in associated surface waters and correlated well with the contamination detected in the surface water. The highest organic contaminant concentrations identified in CS-B sediment samples, where 1,4-dichlorobenzene (220 mg/kg), Aroclor 1248 (480 mg/kg), Aroclor 1254 (141 mg/kg), and Aroclor 1260 (66 mg/kg) were detected. The highest organic contaminant concentrations were: in CS-A, Aroclor 1254 (71 mg/kg); in CS-C, Aroclor 1254 (11 mg/kg); in CS-D, Aroclor 1254 (7.5 mg/kg); and at Site M, Aroclor 1242 (20 mg/kg). A number of the same semivolatiles and PCBs were identified in all four creek sectors. They included benzo(a)pyrene, benzo(b)fluoranthene, pyrene, Aroclor 1254, and Aroclor 1260. Organic contaminants in sediments were generally highest in CS-B, followed by CS-A, CS-C, and CS-D. Organic contaminants detected in Site M sediments consisted of PCBs. The contaminants 1,4-dichlorobenzene, pentachlorophenol, Aroclor 1248, Aroclor 1254, and Aroclor 1260 were detected in their highest concentrations in Creek Sector B which is immediately adjacent to Site G, where extremely high concentrations of these contaminants were detected in surface and subsurface soil samples. Inorganic contaminants were generally highest in CS-A followed by B, C, and D. The highest concentrations of barium and copper were detected on CS-B.

4.2.3 Surface Soil Sampling

4.2.3.1 Results

Surface soil was sampled at two sites (Site G and Site J). Significant results are presented in Figures 4-37, 4-38, 4-39, and 4-40, and Table 4-10. Complete results are in Appendix D. Volatiles, semi-volatiles, pesticides, and PCBs, and inorganic contaminants were detected in the Site G surface soils. Analysis of surface soil samples from Site J revealed only semivolatile and inorganic contamination.

Volatile Organics. Analysis of the 43 surface soil samples from Site G revealed the presence of 12 different volatiles. The most frequently detected volatile and the one with the highest concentration was 4-methyl-2-pentanone, which was detected in 22 samples, with the maximum concentration detected in sample SS-33 at 2.0 mg/kg. Sample SS-38 contained the greatest number of volatiles (seven).

No volatiles were detected in surface soil samples from Site J.

Semivolatile Organics. Analysis of the 43 surface soil samples from Site G revealed semivolatiles in 33 samples. Twenty-six semivolatiles were detected. The compounds with the highest concentrations were 1,4-dichlorobenzene (22,000 mg/kg) and pentachlorophenol (21,000 mg/kg) in samples SS-21 and SS-39, respectively. Pentachlorophenol was detected most frequently (14 times); benzo(a)pyrene was detected 13 times, and pyrene 12 times. Benzo(a)pyrene was detected in 13 samples, the maximum concentration was 22J mg/kg in sample SS-15.

No semivolatiles were detected in surface soils at Site J.

Pesticides and PCBs. Analysis of the 43 surface soil samples from Site G revealed PCBs in 40 samples and the pesticide degradation product 4,4'-DDE in five samples. Three congeners of PCB were detected: Aroclor 1248, Aroclor 1254, and Aroclor 1260. PCBs were detected in six samples at concentrations greater than 1,000 mg/kg. The highest PCB concentration was in sample SS-11, which contained Aroclor 1248 at 24,000 mg/kg; Aroclor 1254 at 29,000 mg/kg; and Aroclor 1260 at 21,000 mg/kg. Five samples contained 4,4-DDE; of these, sample SS-07 contained the highest concentration (0.3 mg/kg). Octachlorodibenzo(b,e)-1,4-dioxin (OCDD) was

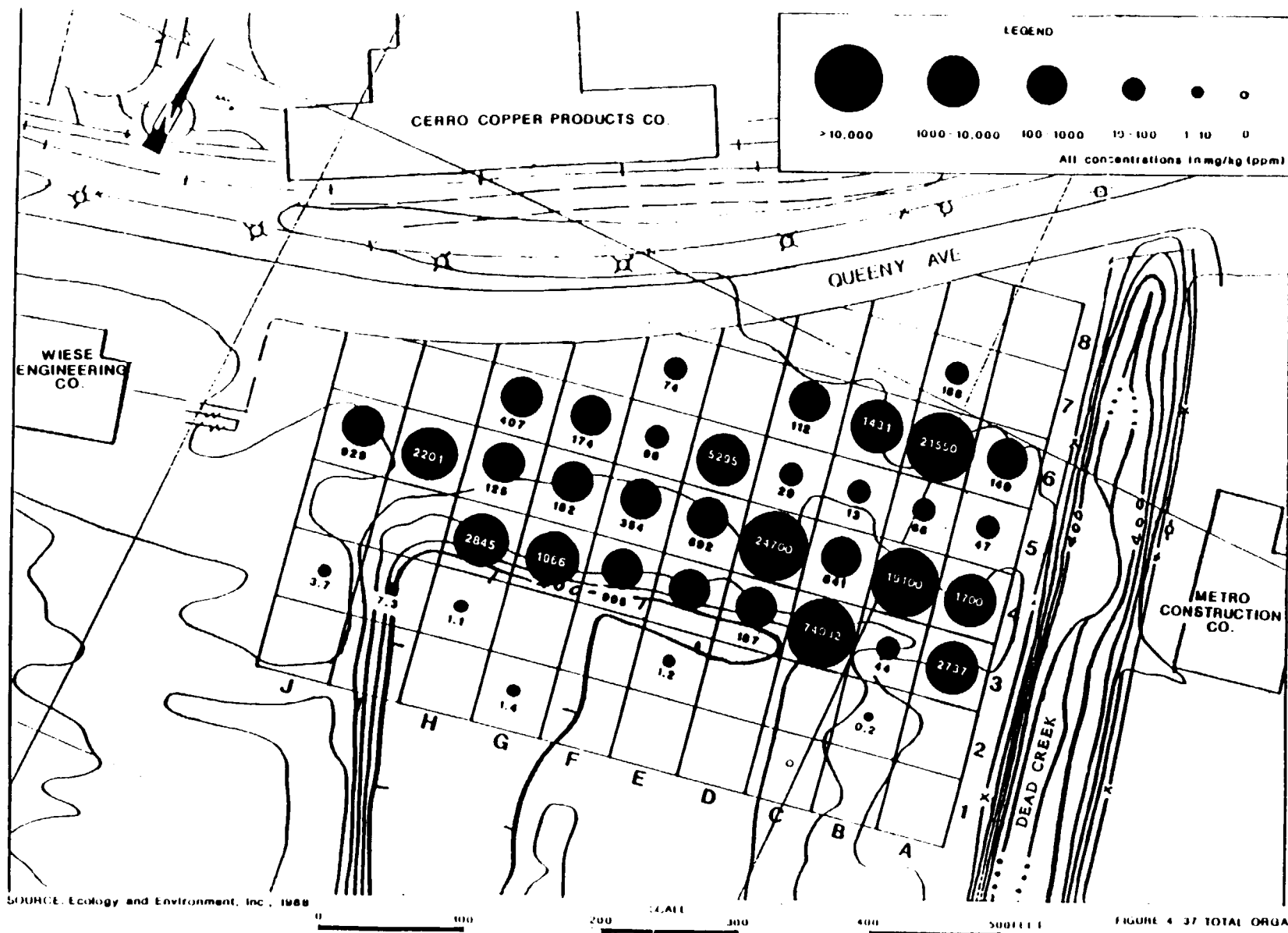


FIGURE 4-37 TOTAL ORGANIC CONCENTRATIONS IN SURFICIAL SOIL AT SITE G

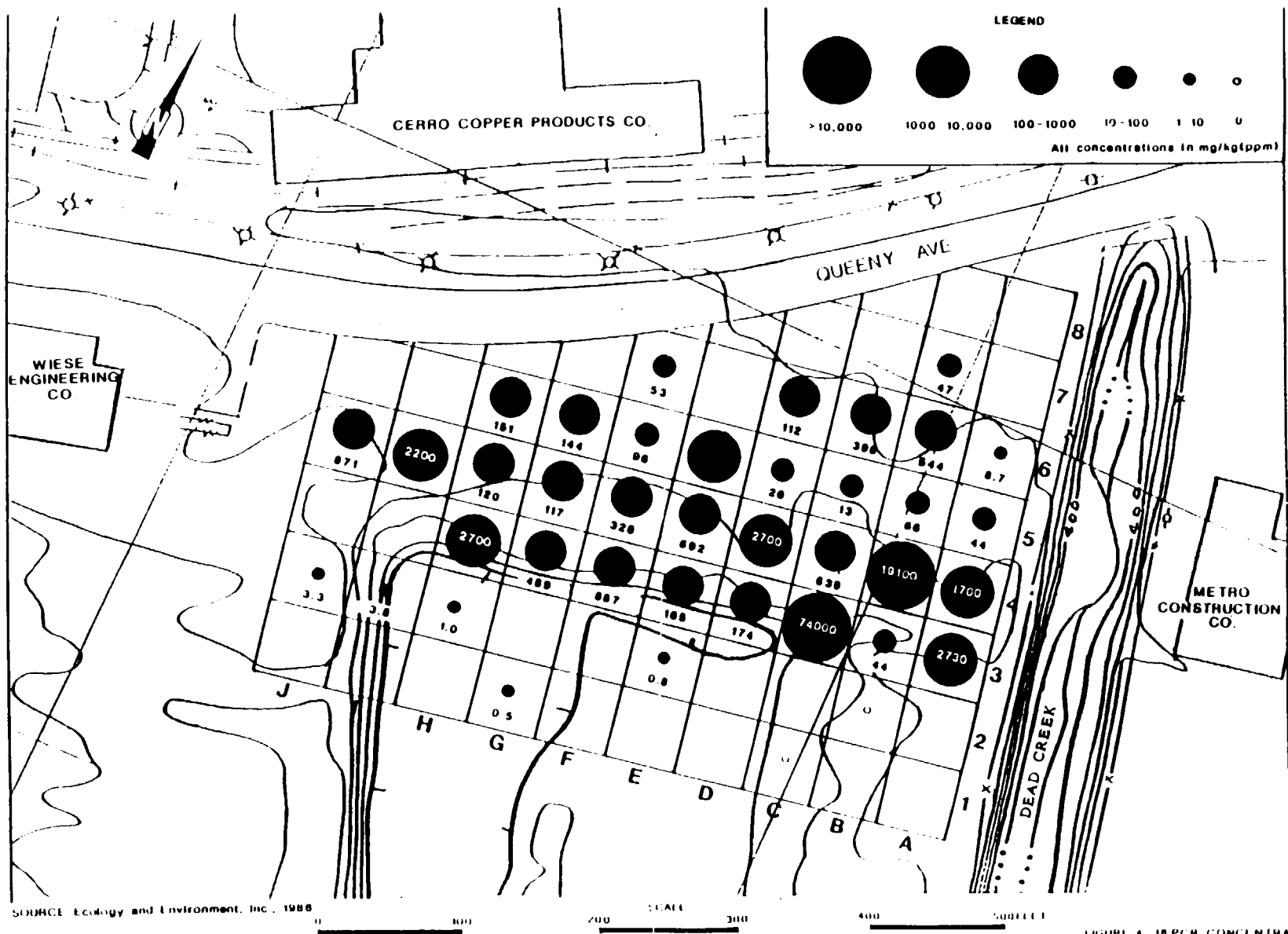
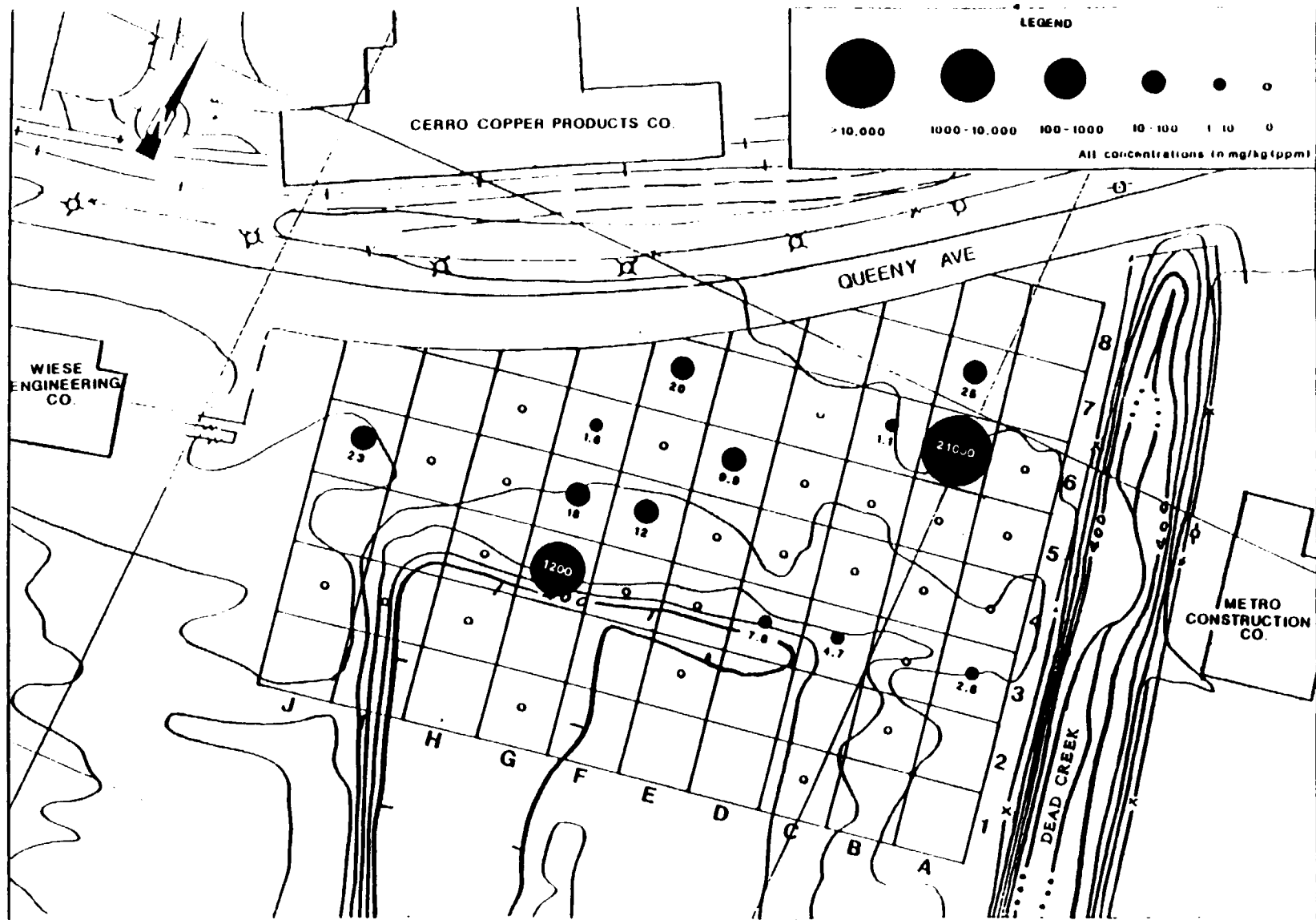


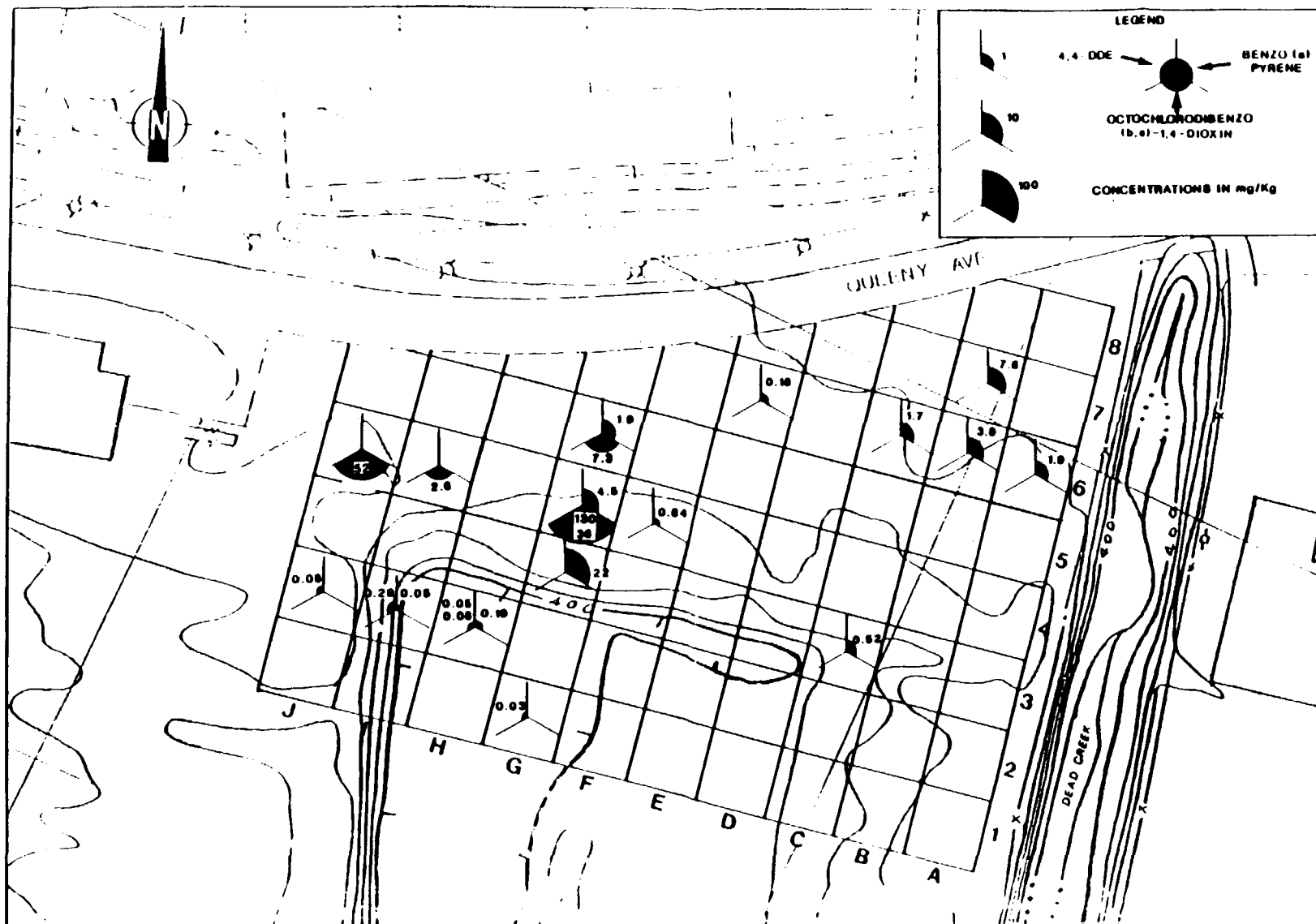
FIGURE 4. PCB CONCENTRATIONS IN SURFACE SOILS AT SITE G



SOURCE: Ecology and Environment, Inc., 1988



FIGURE 4-39 PENTACHLOROPHENOL CONCENTRATIONS IN SURFICIAL SOIL AT SITE G



SOURCE: Ecology and Environment, Inc., 1988.

0 100 200 300 400 500 FEET

FIGURE 4-40 CONCENTRATIONS OF SELECTED ORGANIC CONTAMINANTS IN SURFACE SOILS AT SITE 11

Table 4-10

SUMMARY OF ORGANIC CONTAMINATION OF SURFACE SOIL SAMPLES AT SITE G

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration	Grid Number of Highest Concentration
<u>Volatile Organics</u>				
4-methyl-2-pentanone	22	2	SS-33	D-5
toluene	9	1.4	SS-38	A-6
xylene	2	0.17	SS-38	A-6
ethylbenzene	2	0.14	SS-38	A-6
tetrachlorobenzene	10	0.06	SS-11	C-3
benzene	3	0.08	SS-38	A-6
<u>Semivolatile Organics</u>				
1,4-dichlorobenzene	4	22,000	SS-21	D-4
pentachlorophenol	14	21,000	SS-39	B-6
4-nitrophenol	1	1,000	SS-40	C-6
2-nitroaniline	4	220	SS-37	M-5
naphthalene	11	120	SS-17	M-3
pyrene	12	85	SS-15	G-3
benzo-b-fluoranthene	10	48	SS-16	G-3
chrysene	11	393	SS-15	G-3
1,2,4-trichlorobenzene	8	35	SS-34	E-5
benzo-a-pyrene	13	223	SS-15	G-3
fluoranthrene	11	45	SS-16	G-3
phenanthrene	10	403	SS-15	G-3
dibenzo(a,h)anthracene	6	5.4	SS-43	B-7
indeno(1,2,3-cd)pyrene	5	5.2	SS-43	B-7
dibenzofuran	3	0.93	SS-11	C-3
2,4-dichlorophenol	2	6.2	SS-40	C-6
2-methylnaphthalene	3	13	SS-11	C-3

Table 4-10 (Cont.)

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration	Grid Number of Highest Concentration
benzo(g,h,i)perylene	5	1.5J	SS-43	B-7
benzo(k)fluoranthene	4	10	SS-25	G-4
<u>Pesticides/PCBs</u>				
4,4'-DDE	5	0.3	SS-07	I-2
Aroclor 1248	13	24,000	SS-11	C-3
Aroclor 1254	6	29,000	SS-11	C-3
Aroclor 1260	36	21,000	SS-11	C-3

* A total of 43 surface soil samples were collected at Site G. The numbers listed indicate the number of samples, of the total of 43, in which each compound was detected.

J Estimated values. Result is greater than zero, but less than the specified detection limit.

Source: Ecology and Environment, Inc. 1988.

detected in three samples, with the highest concentration in sample SS-25 (130 mg/kg).

Dioxin. Two composite surface soil samples from Site G were analyzed for 2,3,7,8-TCDD. One was from grid sections B3 through F3, and the other was from grid sections A7, A8, and B6 through B8. Neither sample contained 2,3,7,8-TCDD.

Inorganics. Analysis of the 43 surface soil samples from Site G revealed elevated levels of antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, vanadium, zinc, and cyanide compared to background samples SS-44 and SS-45.

Analysis of the three Site J surface soil samples revealed chromium and nickel concentrations at comparable or higher levels than Site G.

4.2.3.2 Discussion

Although volatiles were detected in 22 of 43 samples, the concentrations of volatiles present in surface soil samples were limited compared to concentrations of other organics detected. This is probably due to the tendency of volatiles to evaporate or to penetrate into subsurface soils. Surface soil sample SS-38 contained the greatest number of volatiles. This sample was collected near the location of subsurface soil sample G8-70, which contained very high concentrations of the same volatiles.

Semivolatiles and PCBs make up the bulk of the contamination detected in surface soils. Figures 4-37, 4-38, 4-39, and 4-40 depict the locations and concentrations of total organics, PCBs, pentachlorophenol, and 4,4'-DDE, benzo(a)pyrene, and octachlorodibenzo(b,e)-1,4-dioxin (OCDD) in surface soil samples at Site G. The heaviest contamination is found across the central 200-foot-wide and 500-foot-long section of Site G which corresponds to the pit location identified in aerial photographs. Although in many cases the PCBs comprised the largest portion of the organic contamination, in a number of areas pentachlorophenol; 1,4-dichlorobenzene; naphthalene; 4-nitrophenol; 2-nitroaniline; and other semivolatiles comprised the largest portion. There is very little pattern to the distribution of the contaminants, other than the high

level of contamination present in the central area of the site. The 4,4'-DDE contamination is confined to a localized strip in the southwest portion of the site. It should be noted that 4,4'-DDE and other contaminants may be present but undetected in some samples due to the use of elevated detection limits, which resulted from the dilution of sample extracts, in accordance with contract laboratory protocol.

Fifteen of the organic chemicals detected were detected in 10 or more samples. This suggests the likelihood that many contaminants which were undetected in certain samples may be present below detection limits used. Because of the highly concentrated nature of the soil samples, many analyses were conducted at a dilution factor of 1,000.

The presence of detected OCDD in three samples suggests the likely presence of 2,3,7,8-TCDD. The compound 2,3,7,8-TCDD and other chlorinated dioxins and furans frequently accompany OCDD, but usually at a lower concentration than the OCDD. The surface soil samples from Site G analyzed for 2,3,7,8-TCDD were from grid sections which did not contain any detected OCDD.

Only one surface soil sample from Site G contained no detectable organic contamination, sample SS-01 from the southeast corner of the site.

The absence of organic contaminants at Site J indicates the general absence of chemical disposal activities at the site.

The inorganic contamination detected at Sites G and J occurred in no obvious pattern of location nor combination of contaminant frequency.

4.2.4 Subsurface Soil Sampling

Subsurface soil samples were collected from Area 1 Sites G, H, and L, Site I/Creek Sector A; from Area 2 Site O; and from peripheral sites J, K, N, and P.

4.2.4.1 Results

Area 1

Analytical results for subsurface soil samples collected from borings at Sites G, H, I, and L are presented in Figure 4-41, and Tables 4-11, 4-12, 4-13, and 4-14. Complete results are in Appendix D. Volat-

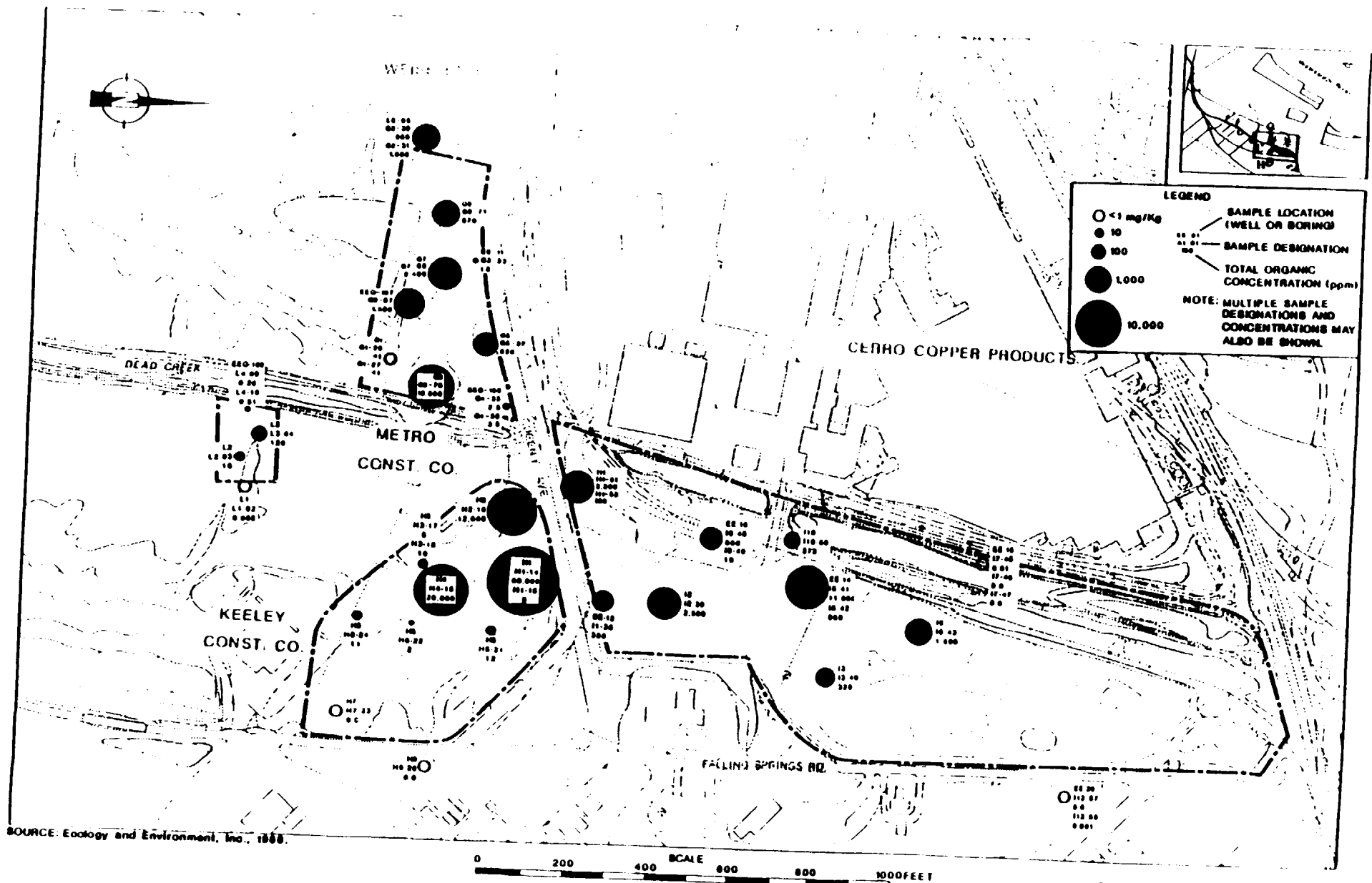


FIGURE 4-41 TOTAL ORGANIC CONCENTRATION
IN SUBSURFACE SOILS AT AREA 1

Table 4-11

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE G

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	9	540E	G7-69
tetrachloroethene	8	58	G8-70
trichloroethene	4	4	G7-69
benzene	7	45	G9-71
toluene	6	117	G6-67
4-methyl-2-pentanone	4	6	G8-70
ethylbenzene	6	17	G7-69
<u>Semivolatile Organics</u>			
phenol	1	177	G5-37
naphthalene	7	5,400	G8-70
2-methylnaphthalene	4	37J	G8-70
1,2,4-trichlorobenzene	4	120J	G7-69
2,4,6-trichlorophenol	1	0.49	G5-37
1,4-dichlorobenzene	3	3J	G4-36
2,4-dichlorophenol	3	141J	G8-70
pentachlorophenol	5	4,800	G7-69
phenanthrene	4	51J	G8-70
dibenzofuran	2	34J	G7-69
pyrene	2	19	G5-37
chrysene	1	23	G5-37

Table 4-11 (Cont.)

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Pesticides/PCBs</u>			
4,4'-DDE	4	135J	Q7-69
Aroclor 1248	1	174C	Q9-71
Aroclor 1260	6	4,400	Q8-70

^a A total of 12 subsurface soil samples were collected from Site G. The numbers listed represent the number of samples, of the total of 12, in which each compound was detected.

E Estimated value. Amount detected in sample exceeds the calibrated range.

J Estimated value. Result is greater than zero, but less than the specified detection limit.

C Result confirmed by GC/MS.

Source: Ecology and Environment, Inc. 1988.

Table 4-12

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE H

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	6	450E	H1-14
toluene	5	76	H4-19
benzene	7	61	H1-14
ethylbenzene	3	11	H4-19
xylene	3	19	H1-14
4-methyl-2-pentanone	3	7.9	H2-16
chloroform	2	0.19	H3-17
tetrachloroethene	1	5.6	H1-14
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	5	31,000E	H1-14
1,2-dichlorobenzene	3	19,000E	H1-14
naphthalene	4	2,300	H2-16
1,2,4-trichlorobenzene	6	7,600	H1-14
1,3-dichlorobenzene	3	240J	H1-14
2,4,6-trichlorophenol	2	610	H1-14
2-methylnaphthalene	3	350	H2-16
phenanthrene	6	2,100	H2-16
4-nitroaniline	1	1,800	H4-19
anthracene	4	680	H2-16
dibenzofuran	4	600	H2-16
benzo(a)pyrene	2	270	H2-16
pyrene	3	660	H2-16

Table 4-12 (Cont.)

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
fluorene	3	480	H2-16
benzo(a)anthracene	3	380	H2-16
fluoranthene	4	1,330	H2-16
<u>Pesticides/PCBs</u>			
4,4'-DDE	2	0.78	H8-24
4,4'-DDD	1	0.43	H5-21
4,4'-DDT	2	0.92	H5-21
Aroclor 1260	7	18,000	H4-19

* A total of 11 subsurface soil samples were collected from Site H. The numbers listed represent the number of samples, of the total of 11, in which each compound was detected.

E Estimated value. Amount detected in sample exceeds the calibrated range.

J Estimated value. Result is greater than zero, but less than the specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 4-13

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE I

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	12	130	I3-40
toluene	11	78	I9-48
benzene	10	24	I5-41
ethylbenzene	10	15	I1-38
xylene	10	19	I1-38
4-methyl-2-pentanone	1	4.2	I6-43
tetrachloroethene	5	5.3	I2-39
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	8	1,400	I11-51
1,2,4-trichlorobenzene	8	8,300E	I5-41
1,2-dichlorobenzene	6	140	I5-41
naphthalene	7	510	I9-48
1,3-dichlorobenzene	2	70	I9-48
2-methylnaphthalene	7	170	I6-43
phenanthrene	5	100	I6-43
hexachlorobenzene	7	1,300	I5-41
pentachlorophenol	1	190	I1-38
anthracene	2	200	I5-41
n-nitrosodiphenylamine	2	100J	I5-41
fluoranthene	3	200	I5-41

Table 4-13 (Cont.)

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
pyrene	4	49J	I6-43
dibenzofuran	1	5.6	I9-48
benzo(a)pyrene	1	2.5	I1-38
benzo(a)anthracene	2	6.7	I10-50
benzo(b)fluoranthene	2	32J	I6-43
fluorene	3	35	I6-43
<u>Pesticides/PCBs</u>			
4,4'-DDD	2	30	I9-48
4,4'-DDT	1	4.3	I9-49
Toxaphene	1	490	I6-43
Aroclor 1260	5	340J	I5-41

* A total of 16 subsurface soil samples were collected from Site I. The numbers listed represent the number of samples, of the total of 16, in which each compound was detected.

E Estimated value. Amount detected in sample exceeds the calibrated range.

J Estimated value. Result is greater than zero, but less than the specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 4-14

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE L

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatiles Organics</u>			
toluene	4	27	L3-04
trans-1,2-dichloroethene	3	20	L3-04
benzene	4	4.2	L3-04
ethylbenzene	1	0.04J	L2-03
xylene	2	0.67J	L3-04
4-methyl-pentanone	4	0.17	L2-03
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	1	0.21J	L3-04
naphthalene	2	0.53J	L3-04
2-methylnaphthalene	2	1.1J	L3-04
methylphenol	2	1.1J	L3-04
phenol	2	1.5J	L3-04
pentachlorophenol	2	58	L3-04
benzo(a)anthracene	1	0.91J	L3-04
chrysene	1	0.2J	L2-03
fluoranthene	1	0.45	L2-03
phenanthrene	2	1.8J	L3-04
<u>Pesticides/PCBs</u>			
None			

* A total of 5 subsurface soil samples were collected from Site L. The numbers listed represent the number of samples, of the total of 5, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than the specified detection limit.

Source: Ecology and Environment, Inc. 1988.

tile, semivolatile, pesticide/PCB, and inorganic contamination were identified at all sites except Site L, where no subsurface pesticide/PCB contamination was detected.

Site G

Volatile Organics. Analysis of the 12 subsurface soil samples from nine borings at Site G revealed a total of 11 volatiles in 11 samples. Samples G6-67 and G8-70 each contained nine detected volatiles. Samples G5-37, G7-69, and G9-71 each contained eight volatiles. The highest concentration of any volatile contaminant detected was 540 mg/kg of chlorobenzene in sample G7-69. Sample G1-27 contained only one volatile, and G1-26 contained none.

Semivolatile Organics. Analysis of the 12 samples of subsurface soils from nine borings at Site G revealed a total of 23 semivolatiles in nine samples. Sample G5-37 contained 14 semivolatiles and sample G9-71 contained 11. The highest concentrations of any semivolatile contaminants were 5,400 mg/kg of naphthalene in sample G8-70 and 4,800 mg/kg of pentachlorophenol in sample G7-69. Field samples G1-26, G1-27, and G3-33 contained no detected semivolatiles.

Pesticides/PCBs. Analysis of the 12 samples of subsurface soils from nine borings at Site G revealed one pesticide and two PCB congeners. The pesticide, 4,4-DDE, was detected in four samples (G2-30, G2-31, G6-67, and G7-69). The highest concentration detected was 135J mg/kg in sample G7-69. Aroclor-1260 was detected in six samples, with a high concentration of 4,400 mg/kg in G8-70. Aroclor-1248 was detected in one sample (G9-71), at a concentration of 174 mg/kg.

Inorganics. Analysis of the 12 samples of subsurface soils from nine borings at Site G revealed elevated concentrations of arsenic, barium, chromium, cobalt, copper, lead, mercury, nickel, and vanadium when compared to background soil samples GB-29, GB-34, and GB-68. The highest concentrations were about 100 times background concentrations.

Site H

Volatile Organics. Analysis of the 11 field samples of subsurface soil from nine borings at Site H revealed a total of 10 volatiles in seven samples. Sample H3-17 contained seven detected volatiles. Samples H1-14 and H2-16 each contained six volatiles and sample H4-19 contained five detected volatiles. The highest concentration of any volatile contaminant was 450 mg/kg of chlorobenzene in sample H1-14. Field samples H5-21, H7-23, H8-24, and H9-28 contained no volatiles and sample H6-22 contained only one.

Semivolatile Organics. Analysis of the 11 samples of subsurface soil from nine borings at Site H revealed a total of 32 semivolatiles in nine samples. Sample H2-16 contained 21 semivolatiles. The highest concentrations of any semivolatile contaminants were 31,000E mg/kg of 1,4-dichlorobenzene; 19,000 mg/kg of 1,2-dichlorobenzene; and 7,600 mg/kg of 1,2,4-trichlorobenzene in sample H1-14. Other high concentrations included 2,300 mg/kg of naphthalene; 2,100 mg/kg of phenanthrene; and 1,330 mg/kg of fluoranthene in sample H2-16. Sample H2-16 contained 17 detected semivolatiles at concentrations greater than 100 mg/kg, including benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzofuran, pyrene, and anthracene. Field samples H7-23 and H9-28 contained no detected semivolatiles.

Pesticides/PCBs. Analysis of the 11 samples of subsurface soil from nine borings at Site H revealed three pesticides and one PCB congener. The pesticides, 4,4'-DDE and 4,4'-DDT, were detected in samples H5-21 and H8-24. The pesticide 4,4'-DDD was detected in one sample, H5-21. The highest pesticide concentration was 0.9 mg/kg of 4,4'-DDT in sample H5-21. Aroclor 1260 was detected in six samples. The highest Aroclor 1260 concentration was detected in H4-19 at a concentration of 18,000 mg/kg.

Inorganics. Analysis of the 11 samples of subsurface soils from nine borings at Site H revealed elevated concentrations of arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, zinc, and

cyanide. High concentrations were generally ranged from 10 to 1,000 times background.

Site I/Creek Sector A

Volatile Organics. Analysis of the 16 samples of subsurface soil from 10 borings at Site I/CS-A revealed a total 10 volatiles in thirteen samples. Sample I10-50 contained eight volatiles. Samples I5-41 contained seven volatiles; and samples I2-39, I5-42, and I6-43 contained six volatiles. The highest concentration of any volatile contaminant was 130 mg/kg of chlorobenzene in sample I3-40. Samples I7-45 and I12-58 contained only one detected volatile, and samples I7-46, I7-47, and I12-57 contained no volatiles.

Semivolatile Organics. Analysis of the 16 samples of subsurface soils from 10 borings at Site I/CS-A revealed a total of 25 semivolatiles in 11 samples. Sample I6-43 contained 15 detected semivolatiles. The highest concentrations of any semivolatile contaminants were 8,300E mg/kg of 1,2,4-trichlorobenzene and 1,300 mg/kg of hexachlorobenzene in sample I5-41; 1,800 mg/kg of 1,4-dichlorobenzene in sample I11-51; and 510 mg/kg of naphthalene in sample I9-48. Sample I5-41 contained five additional semivolatiles at concentrations greater than 100 mg/kg, including fluoranthene; anthracene; n-nitrosodiphenylamine; 1,2-dichlorobenzene; and 1,4-dichlorobenzene. Samples I7-45, I7-46, I7-47, I12-57, and I12-58 contained no detected semivolatiles.

Pesticides/PCBs. Analysis of the 16 field samples of subsurface soils for 10 borings at Site I/CS-A revealed three pesticides and one PCB congener. The pesticides were 4,4'-DDD, 4,4'-DDT, and toxaphene. Toxaphene was detected at a concentration of 490 mg/kg in I6-43; 4,4'-DDD was detected in I9-48 and I9-49 at 30 and 6.6 mg/kg, respectively; and 4,4'-DDT was detected in I9-49 at 4.3 mg/kg. Aroclor 1260 was detected in four samples; the highest concentration was 340J mg/kg in I5-41.

Inorganics. Analysis of the 16 samples of subsurface soils from 10 borings at Site I/CS-A revealed elevated concentrations of antimony,

chromium, copper, lead, mercury, nickel, vanadium, and cyanide. High concentrations ranged from 20 to greater than 3000 times background concentrations.

Site L

Volatile Organics. Analysis of the five samples of subsurface soils from four borings at Site L revealed a total of six volatiles in five samples. Sample L3-04 contained the highest concentration of any volatile contaminant, 27 mg/kg of toluene. Five volatiles were detected in sample L2-03, and four were detected in samples L3-04, L4-09, and L4-10.

Semivolatile Organics. Analysis of the five samples of subsurface soil from four borings at Site L revealed a total of 13 semivolatiles in three samples. Sample L2-03 contained nine semivolatiles, and sample L3-04 contained eight. The highest concentration was 58 mg/kg of penta-chlorophenol, in L3-04. Samples L1-02 and L4-09 contain no semivolatiles, and sample L4-10 contained only one.

Pesticides/PCBs. No pesticides or PCBs were detected in Site L subsurface soils samples.

Inorganics. Analyses of the five samples of subsurface soil from four borings at Site L revealed elevated concentrations of antimony, copper, lead, and nickel. The high concentrations of antimony and nickel were about 100 times background concentrations, and the high concentrations of copper and lead were 2 to 5 times background.

Area 2

Analytical results for subsurface soil samples from Site 0 are presented in Figure 4-42 and Table 4-15. Complete results are presented in Appendix D.

Site 0

Volatile Organics. Analysis of the 11 samples of subsurface soils from 10 borings at Site 0 revealed a total of 12 volatiles in nine

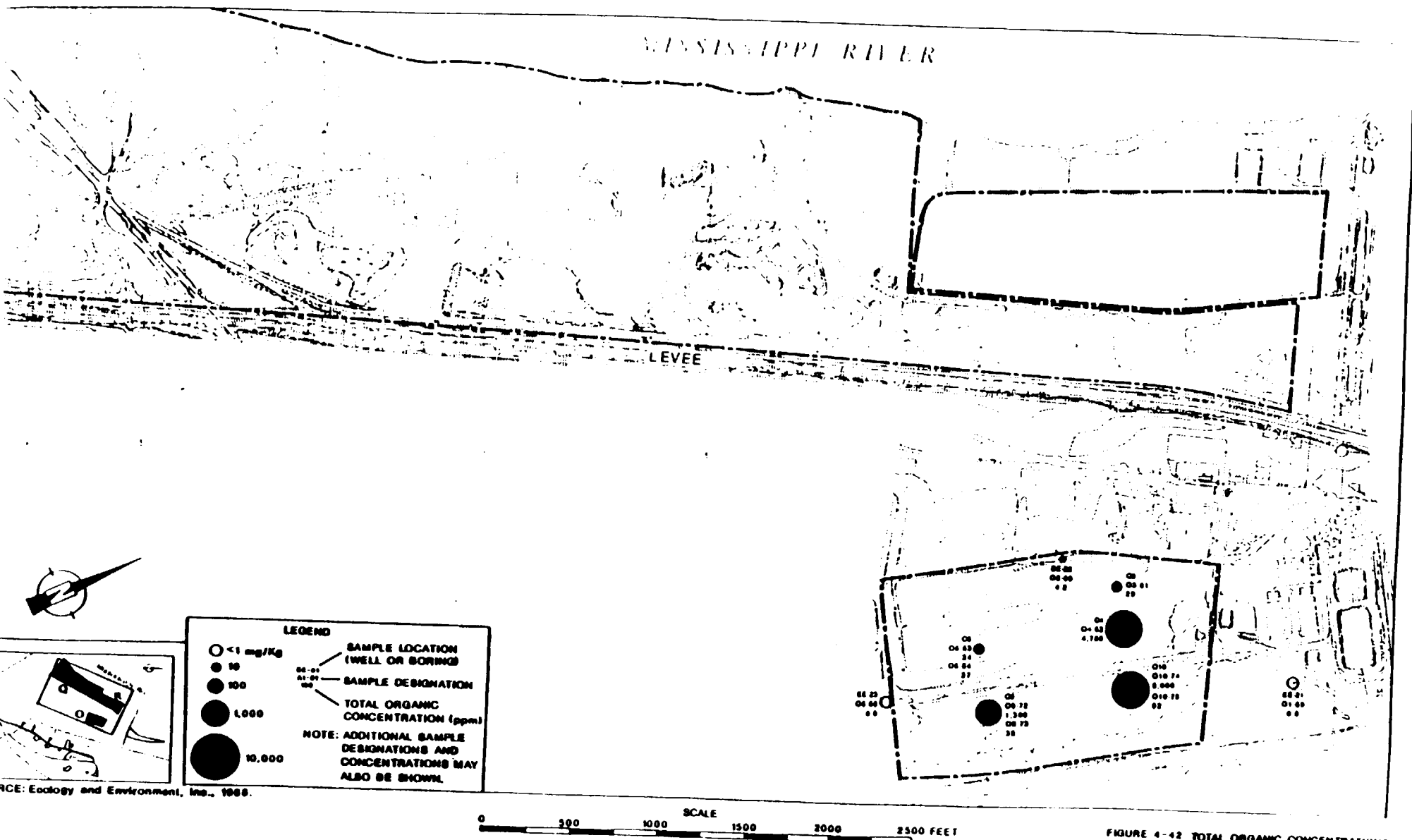


FIGURE 4-42 TOTAL ORGANIC CONCENTRATIONS
IN SUBSURFACE SOILS AT AREA E

Table 4-15

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE 0

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
xylene	9	620E	04-62
ethylbenzene	9	170E	04-62
chlorobenzene	8	59	010-74
toluene	3	29	04-62
benzene	5	31	04-62
1,1,1-trichloroethene	1	1.4	04-62
4-methyl-2-pentanone	2	7.7	04-62
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	2	110	010-74
1,2-dichlorobenzene	2	100	010-74
1,2,4-trichlorobenzene	2	27	04-62
naphthalene	2	35	04-62
methylnaphthalene	3	160	04-62
pentachlorophenol	6	470	04-62
benzo(a)pyrene	2	67	04-62
benzo(b)fluoranthene	2	79	04-62
chrysene	6	280	04-62
benzo(a)anthracene	2	120	04-62
pyrene	5	280	04-62
butylbenzylphthalate	2	3,800E	010-74
fluoranthene	3	44	04-62

Table 4-15 (Cont.)

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
phenanthrene	5	220	04-62
dibenzofuran	1	1.5	09-72
n-nitrosodiphenylamine	2	50J	04-62
<u>Pesticides/PCBs</u>			
Aroclor 1232	2	30	05-64
Aroclor 1242	5	1,900	04-62
Aroclor 1260	2	5.5JC	05-63

^a A total of 11 subsurface soil samples were collected from Site O. The numbers listed represent the number of samples, of the total of 11, in which each compound was detected.

E Estimated value. Amount detected in sample exceeds the calibrated range.

J Estimated value. Result is greater than zero but less than the specified detection limit.

C Identification confirmed by GC/MS.

Source: Ecology and Environment, Inc. 1988.

samples. Sample 02-60 contained 11 volatiles. The highest concentration of any volatile contaminant was 620E mg/kg xylenes in sample 04-62. Sample 01-59 and 06-66 contained no volatile organics.

Semivolatile Organics. Analyses of the 11 samples of subsurface soils from 10 borings at Site 0 revealed a total of 19 semivolatile organic contaminants in eight samples. Sample 09-72 contained 19 semivolatiles; sample 04-62 contained 14 semivolatiles; and sample 010-74 contained nine semivolatiles. The highest concentrations were 3,800E mg/kg of butyl benzylphthalate; 110 mg/kg of 1,4-dichlorobenzene; and 100 mg/kg of 1,2-dichlorobenzene in 010-74; and 470 mg/kg of pentachlorophenol, 280 mg/kg of pyrene and 280 mg/kg of chrysene in sample 04-62. Samples 01-59, 02-60, and 06-66 contained no semivolatiles.

Pesticides/PCBs. Analysis of the 11 samples of subsurface soils from 10 borings at Site 0 revealed three PCBs in seven samples. Aroclor 1242 was detected in five samples. The highest concentration was 1,900 mg/kg, in sample 04-62. Aroclor 1232 and Aroclor 1260 were also detected in two samples, 05-64 and 05-63, respectively. No PCBs were detected in 01-59, 02-60, 03-61, and 06-66.

Inorganics. Analysis of the 11 samples of subsurface soils from 10 borings at Site 0 revealed elevated concentrations of cadmium, copper, mercury, and nickel. High concentrations ranged from 5 to 100 times background concentrations.

Peripheral Sites

Analytical results for subsurface soil samples collected from borings at Sites J, K, N, and P are presented in Figures 4-43, 4-44, 4-45, and 4-46, and Tables 4-16, 4-17, 4-18, and 4-19, respectively. Complete results are in Appendix D.

Site J

Volatile Organics. Analysis of the three samples of subsurface soils from three borings at Site J revealed three volatiles in two samples. Field sample J2-12 contained 2 mg/kg of ethylbenzene and 8

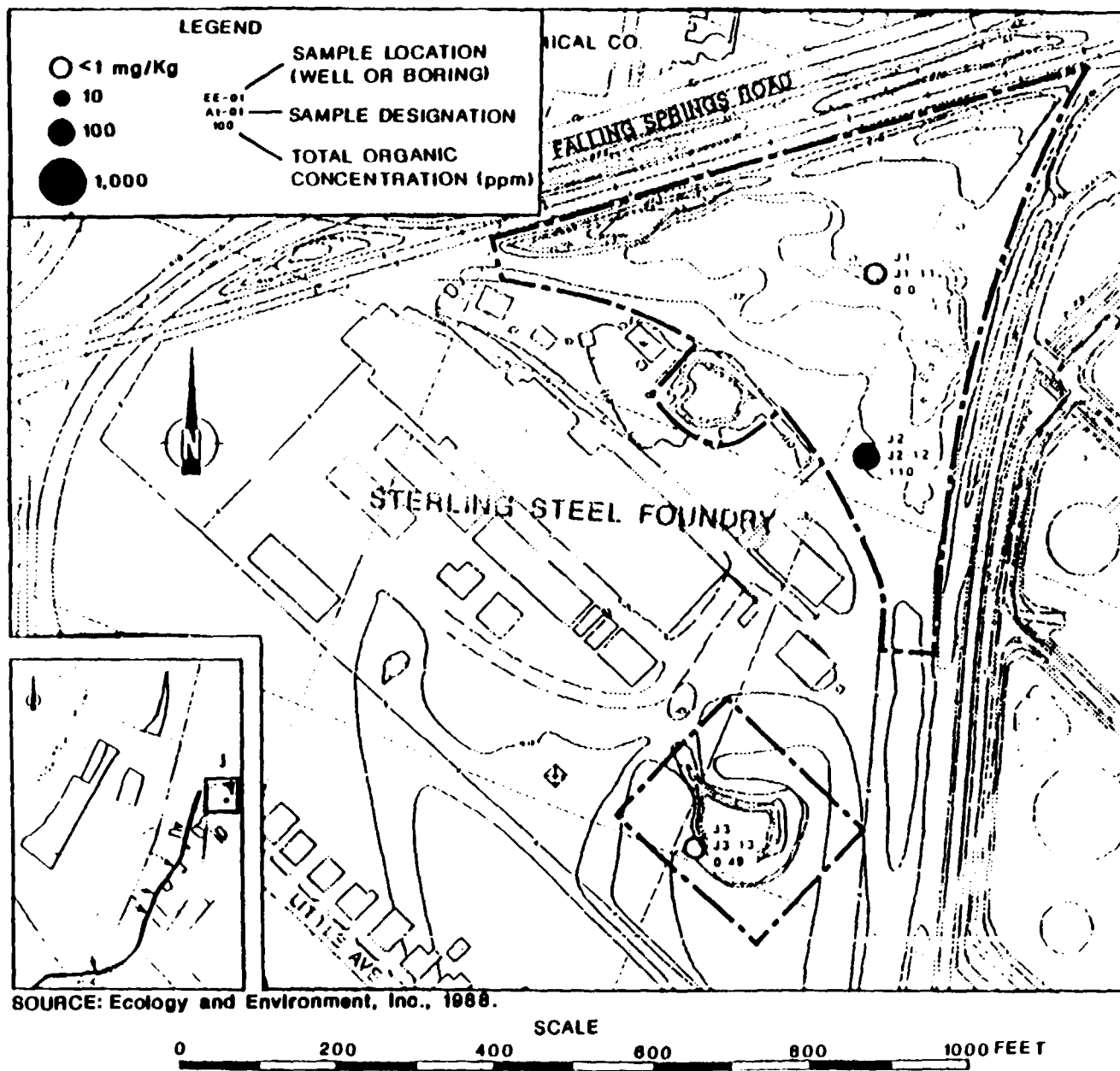


FIGURE 4-43 TOTAL ORGANIC CONCENTRATIONS IN SUBSURFACE SOILS AT SITE J

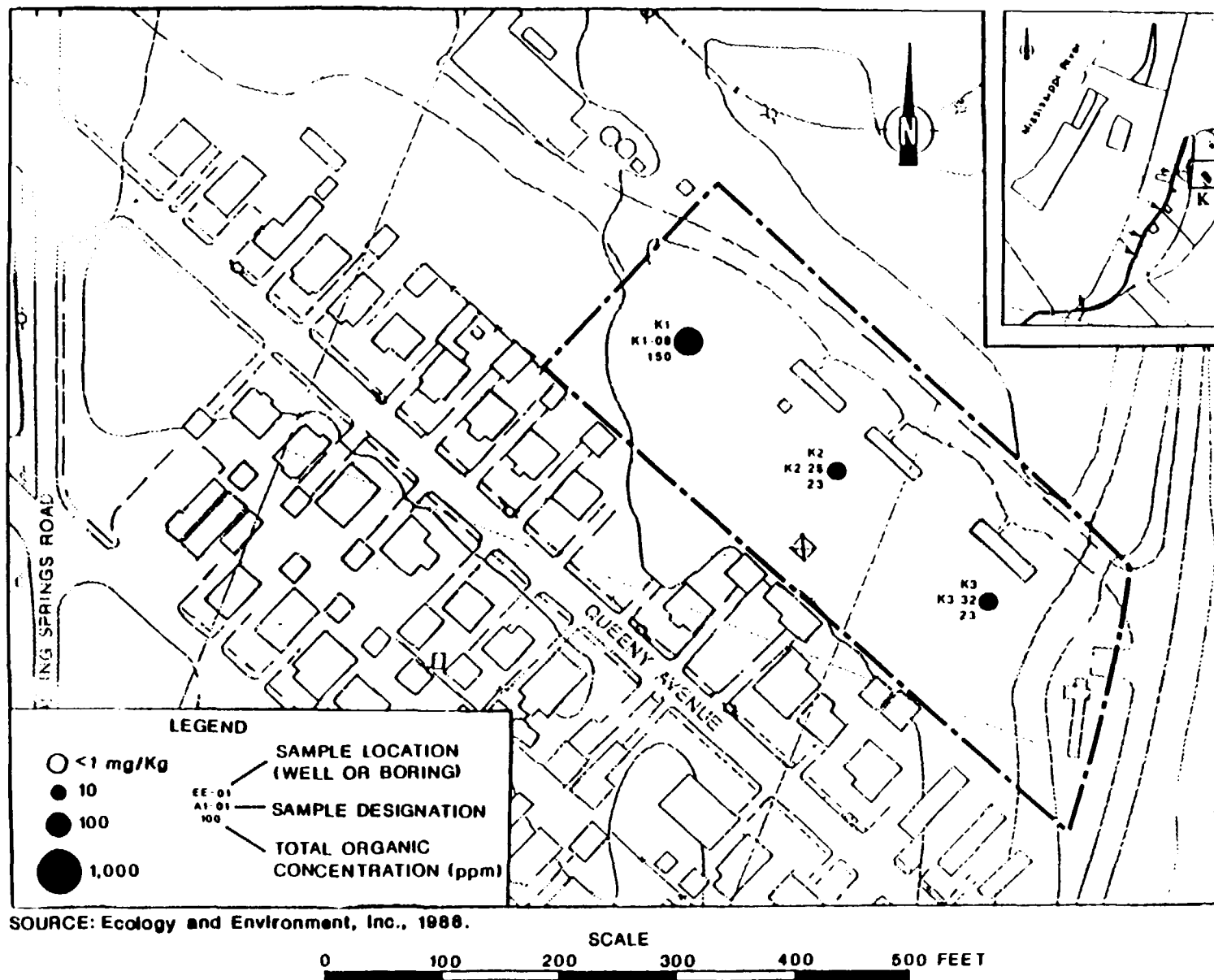


FIGURE 4-44 TOTAL ORGANIC CONCENTRATIONS IN SUBSURFACE SOILS AT SITE K

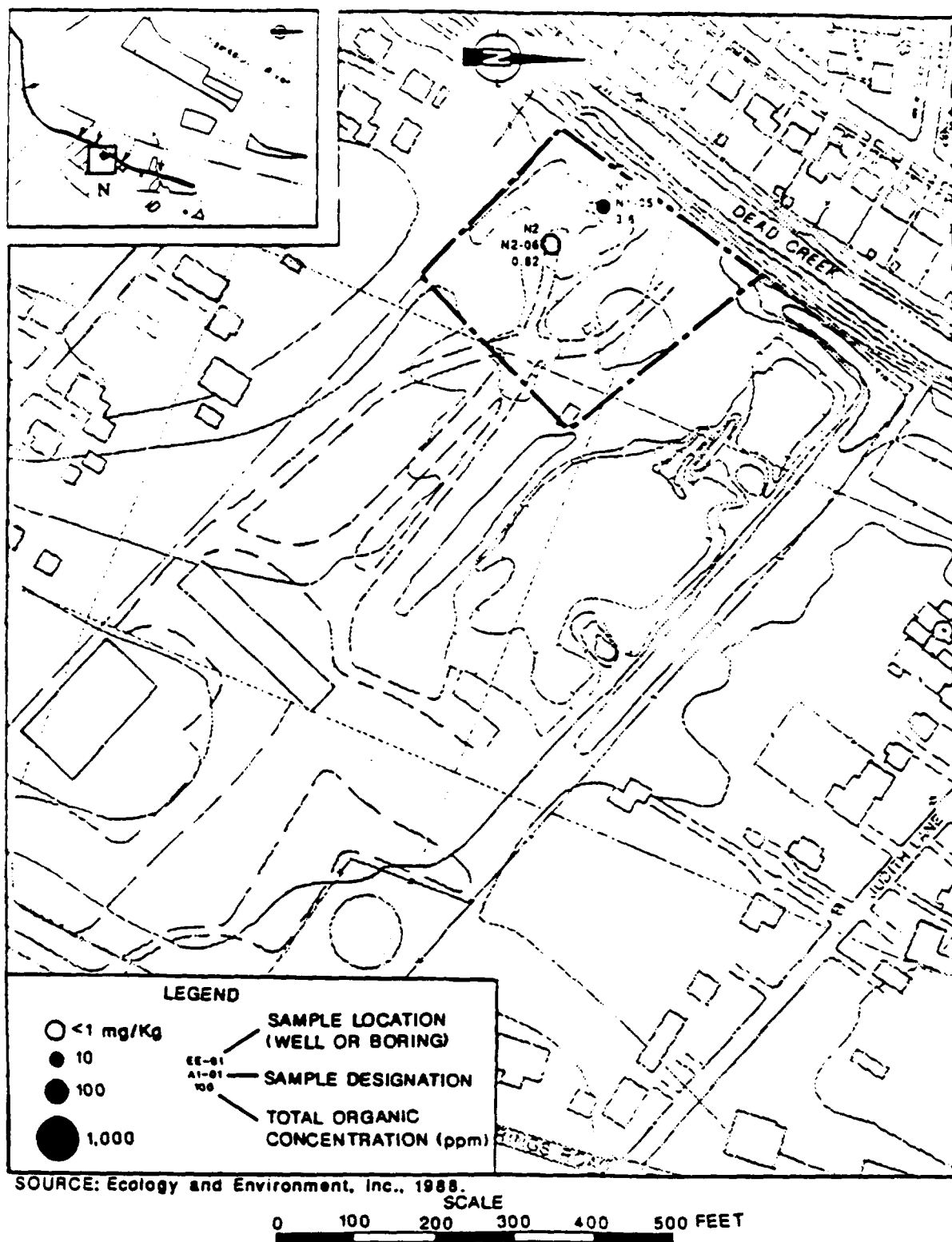


FIGURE 4-45 TOTAL ORGANIC CONCENTRATIONS IN SUBSURFACE SOILS AT SITE N

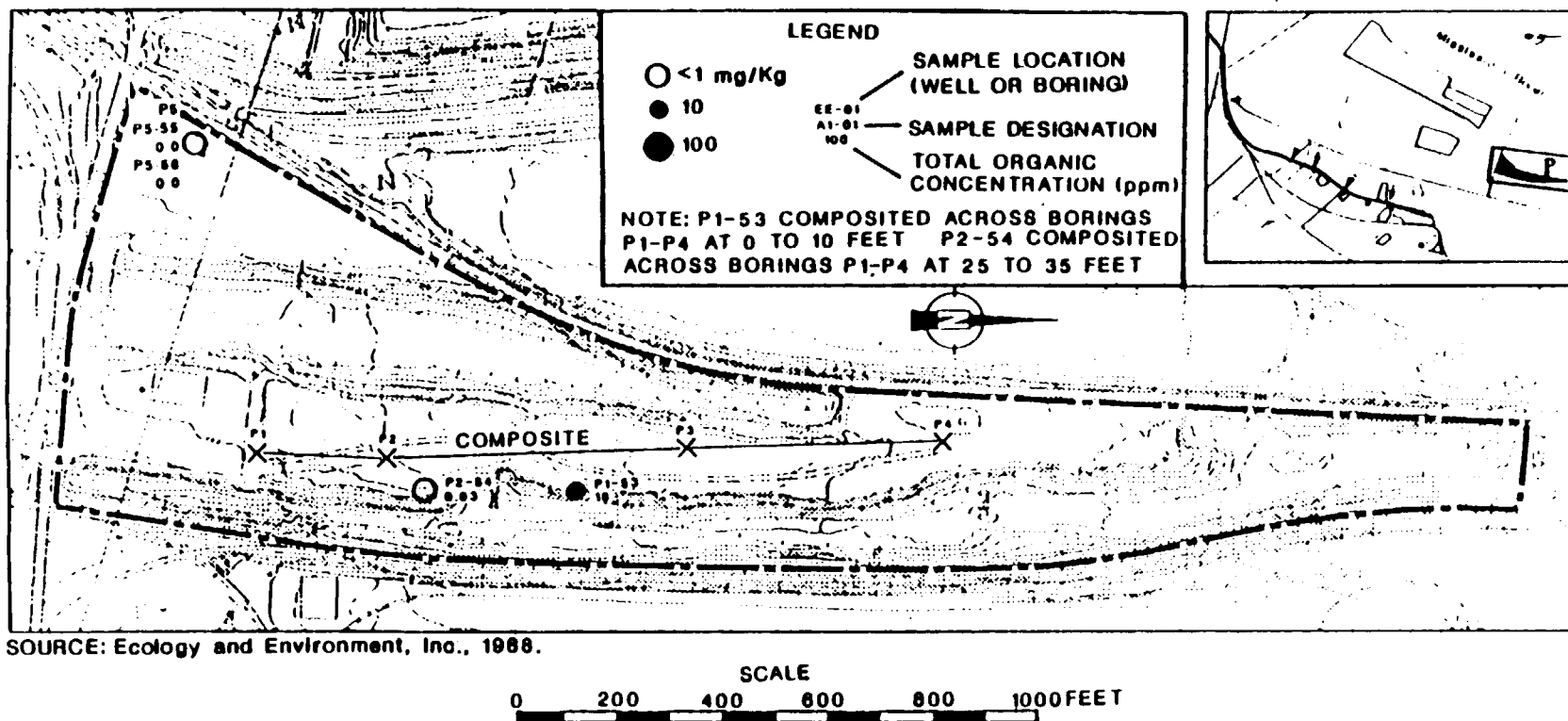


FIGURE 4-46 TOTAL ORGANIC CONCENTRATIONS IN SUBSURFACE SOILS AT SITE P

Table 4-16

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE J

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
ethylbenzene	1	2	J2-12
xylene	1	8	J2-12
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	1	0.21J	J3-13
1,2-dichlorobenzene	1	0.1J	J3-13
naphthalene	1	18	J2-12
2-methylnaphthalene	1	61	J2-16
dibenzofuran	1	1J	J2-12
fluorene	1	3.5J	J2-12
phenanthrene	1	14	J2-12
anthracene	1	0.91J	J2-12
<u>Pesticides/PCBs</u>			
Aroclor 1260	1	0.18	J3-13

* A total of 3 subsurface soil samples were collected from Site J. The numbers listed represent the number of samples, of the total of 3, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than the specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 4-17

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS AT SITE K

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
toluene	1	0.015	K1-08
4-methyl-2-pentanone	1	0.011J	K1-08
<u>Semivolatile Organics</u>			
naphthalene	2	0.15J	K1-08
1,2,4-trichlorobenzene	1	0.096J	K1-08
2-methylnaphthalene	1	0.12J	K1-08
dibenzofuran	2	0.13J	K1-08
phenanthrene	3	1.7	K2-25
pyrene	3	1.8J	K1-08
fluoranthene	3	2.2	K2-25
benzo(a)pyrene	3	0.94	K2-25
benzo(a)anthracene	3	0.94J	K1-08
benzo(b)fluoranthene	3	1.2	K2-25
chrysene	3	1.0	K1-08
<u>Pesticides/PCBs</u>			
Aroclor 1242	1	19	K3-32
Aroclor 1248	2	120C	K1-08
Aroclor 1260	1	6.3	K2-25

* A total of 3 subsurface soil samples were collected from Site K. The numbers listed represent the number of samples, of the total of 3, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

C Identification confirmed by GC/MS.

Source: Ecology and Environment, Inc. 1988.

Table 4-18

SUMMARY OF SUBSURFACE SOIL SAMPLING RESULTS FOR SITE M

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
4-methyl-2-pentanone	1	0.004J	M1-05
<u>Semivolatile Organics</u>			
phenanthrene	2	0.43	M1-05
fluoranthene	2	0.60	M1-05
pyrene	2	0.55	M1-05
benzo(a)anthracene	1	0.26J	M1-05
chrysene	1	0.28J	M1-05
benzo(b)fluoranthene	2	0.29J	M1-05
benzo(a)pyrene	1	0.21J	M1-05
<u>Pesticides/PCBs</u>			
None detected.			

* A total of 2 subsurface soil samples were collected from Site M. The numbers listed represent the number of samples, of the total of 2, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 4-19

SUMMARY OF SUBSURFACE SOIL SAMPLE RESULTS FOR SITE P

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
ethylbenzene	1	0.12	P1-53
toluene	1	0.41	P1-53
chloroform	1	0.01	P1-53
benzene	1	0.05	P1-53
4-methyl-2-pentanone	2	0.05	P1-53
chlorobenzene	1	0.14	P1-53
xylenes	1	0.45	P1-53
hexanone	2	0.05	P1-53
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	1	8.9J	P1-53
1,2-dichlorobenzene	1	3.6J	P1-53
phenol	1	3.9J	P1-53
<u>Pesticides/PCBs</u>			

None detected.

^a A total of 4 subsurface soil samples were collected from Site P. The numbers listed represent the number of samples, of the total of 4, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

Source: Ecology and Environment, Inc. 1988.

mg/kg of xylenes. No volatiles were detected in J1-11. One volatile was detected in sample J3-13.

Semivolatile Organics. Analysis of the three samples of subsurface soils from three borings at Site J revealed ten semivolatile organics contaminants in two samples. Sample J2-12 contained eight semivolatiles, and sample J3-13 contained two semivolatiles. The highest concentrations of semivolatiles were 18 mg/kg of naphthalene, 61 mg/kg of 2-methylnaphthalene, and 14 mg/kg of phenanthrene, in sample J2-12. Field sample J1-11 contained no detected semivolatiles.

Pesticides/PCBs. Analysis of the three samples of subsurface soils from three borings at Site J revealed one PCB congener in one sample. Aroclor 1260 was detected at a concentration of 0.18 mg/kg in sample J3-13. No PCBs were detected in samples J1-11 or J2-12. No pesticides were detected.

Inorganics. Analysis of the three samples of subsurface soils from three borings at Site J revealed no elevated levels of inorganics in any of the samples.

Site K

Volatile Organics. Analysis of the three samples of subsurface soils from three borings at Site K revealed two volatiles in sample K1-08. No volatile organics were detected in samples K2-25 or K3-32.

Semivolatile Organics. Analysis of the three samples of subsurface soils from three borings at Site K revealed 17 semivolatiles in three samples. Sample K2-25 contained 14 detected semivolatiles. Sample K1-08 contained 13 detected semivolatile compounds, and sample K3-32 contained seven semivolatiles. The highest concentrations of any semivolatile contaminants were 1.7 mg/kg of phenanthrene, 2.2 mg/kg of fluoranthene, and 1.2 mg/kg of benzo(b)fluoranthene in sample K2-25, and 1.8J mg/kg of pyrene in sample K1-08.

Pesticides/PCBs. Analysis of the three samples of subsurface soils from three borings at Site K revealed three PCBs in three samples. Sample K1-08 contained 1200 mg/kg of Aroclor 1248, sample K2-25 contained 4.8 mg/kg of Aroclor 1248 and 6.3 mg/kg of Aroclor 1260, and sample K3-32 contained 19 mg/kg of Aroclor 1242. No pesticides were detected in any of the samples.

Inorganics. Analysis of the three samples of subsurface soils collected from three borings at Site K revealed elevated concentrations of tin, mercury, and cyanide. High tin concentrations were about three times background concentrations.

Site N

Volatile Organics. Analysis of the two samples of subsurface soils from two borings at Site N revealed one volatile organic in sample N1-05. No volatiles were detected in sample N2-06.

Semivolatile Organics. Analysis of the two samples of subsurface soils from two borings at Site N revealed seven semivolatile organics in sample N1-05 and four semivolatile organics in sample N2-06.

Pesticides/PCBs. Analysis of the two field samples of subsurface soils from two borings at Site N revealed no pesticides or PCBs.

Inorganics. Analysis of the two field samples of subsurface soils collected from two borings at Site N revealed elevated levels of mercury in sample N2-06.

Site P

Volatile Organics. Analysis of the four samples of subsurface soils collected from two borings at Site P revealed eight volatiles in sample P1-53 and two volatiles in sample P2-54. No volatiles were detected in samples P5-55 and P5-56. The highest concentrations of any volatile contaminants detected were 0.41 mg/kg of toluene and 0.45 mg/kg of xylenes in sample P1-53.

Semivolatile Organics. Analysis of the four samples of subsurface soils collected from two borings at Site P revealed 3.9J mg/kg of phenol, 8.9J mg/kg of 1,4-dichlorobenzene, and 3.6J mg/kg of 1,2-dichlorobenzene in sample P1-53. No semivolatile contaminants were detected in samples P2-54, P5-55, or P5-56.

Pesticides/PCBs. Analysis of the four samples of subsurface soils collected from two borings at Site P revealed no pesticide or PCB contaminants.

Inorganics. Analysis of the four samples of subsurface soils collected from two borings at Site P revealed elevated levels of lead in sample P5-55 and cyanide in samples P5-55 and P2-54. The lead concentration in sample P5-55 is five to ten times background levels.

4.2.4.2 Discussion

Area 1

Examination of the results of the subsurface soil sampling of borings at Sites G, H, I, and L reveals contamination at all sites and in most borings. Site H exhibited the greatest quantity of contamination. Sample H1-14 contained 6% organic chemical contaminants, sample H4-19 contained 2% organic chemical contaminants, and sample H2-16 contained 1.2% organic chemical contaminants. Samples from Sites G and I included samples which contained 1% (G8-70) and 1.1% (I5-41) organic chemical contamination. Samples from Site L were relatively less contaminated, but one sample contained more than 0.01% organic chemical contaminants.

Site G. Samples from borings G-5, G-6, G-7, G-8, and G-9 all exhibited substantial organic contamination. These borings had many of the same contaminants. Aroclor 1260, naphthalene, xylenes, ethylbenzene, chlorobenzene, toluene, 4-methyl-2-pentanone, and benzene were detected in samples from all five borings. Numerous other contaminants were common to three or four of the borings. Because generally only one sample was analyzed per boring and because samples were composited from

various depths within each boring, a specific depth profile of the individual contaminants cannot be made. However, because the samples analyzed were composited from samples collected from different depths for each boring (5-15 ft, 10-20 ft, 10-25 ft, 20-30 ft, and 35-40 ft), the presence of common contaminants in each sample plus visual examination and HNu readings of boring residues suggests the likelihood of fairly continuous contamination throughout each of the boring locations. Many samples contained numerous tentatively identified compounds, present at hundreds and sometimes thousands of mg/kg. Analysis of sample G2-30 tentatively identified the coeluted presence of octachlorodibenzofuran and octachlorodibenzo(b,e)-1,4-dioxin at 120J mg/kg. These compounds were not detected in the analysis of the duplicate samples.

Site H. Samples from borings H1, H2, and H4 all exhibited substantial contamination. Samples from borings H3, H5, and H8 exhibited lower concentrations of contaminants, but each contained numerous contaminants in the 0.1 to 5.0 mg/kg concentration range. Although sample H1-14 contained only 13 organic contaminants, the concentration of contaminants present in the sample required the use of medium-concentration methodology and a dilution factor of 2,000 for the semivolatile and pesticide/PCB fractions. As a result, many contaminants present in concentrations in the 10 to 300 mg/kg range were more likely undetected than not present. Similarly, for sample H4-19, a pesticide/PCB analysis dilution factor of 20,000 raised the detection limits of all three compounds to 160 mg/kg or greater. The detection limits for 4,4'-DDD were 320 mg/kg. However, laboratory analyses tentatively identified 4,4'-DDD at 98J mg/kg and 2,4'-DDD at 8.9 mg/kg.

The heaviest contamination detected was found in the north and northwest portion of Site H, where borings H1, H2, and H4 are located. The absence of contamination at boring locations H7 and H9 indicates that disposal activities were limited to the western two-thirds of the site. The middle third of the site had lower levels of contamination than the western third.

Site I. Samples from borings I5, I11, I2, I6 and I9 all exhibited substantial contamination. Samples from borings I1, I10 and I3 exhi-

bited lower concentrations of contaminants, but each contained numerous contaminants including some detected in excess of 100 mg/kg.

The composite sample taken from 5 ft to 27.5 ft at boring I-5 exhibited the highest amount of contamination of the subsurface samples at Site I/CS-A. The sample from boring I2 and the 6 ft to 20 ft composite sample from boring I11 exhibited the next highest amount of contamination, followed by samples from I6, I9, I1, I10 and I3. The five samples taken from borings I7 and I12 indicate the absence of subsurface soil contamination at these locations.

The heaviest subsurface soil contamination at Site I/CS-A was found generally along a line running north-south near the center of the site. The area encompassing borings I6, I5, I2, and I11 is the area of greatest subsurface soil contamination. Borings I3, I1, I9, and I10, though they revealed substantial contamination, appear to be located on the edge of most heavily contaminated zone. Borings I7 and I12 are outside the contaminated subsurface soil zone.

Contamination was detected in borings I5 and I11 in samples from depths greater than 25 feet, but to a lesser degree than in samples from the upper 25 feet. This indicates that waste disposal at Site I/Creek Sector A occurred at depths shallower than 25 to 30 feet.

Samples from various borings at Site I had numerous contaminants in common. Common contaminants included 1,2-dichlorobenzene; 1,4-dichlorobenzene; 1,2,4-trichlorobenzene; and hexachlorobenzene. Many contaminants found at Site I were also found at Site H.

Site L. Of the Site L subsurface soil samples, samples from borings L2 and L3 exhibited the greatest contamination. However, contamination in these samples was substantially lower than the levels detected at Sites G, H, and I. Subsurface soils in borings L1 and L4 exhibited only contamination with volatile organics, with a maximum concentration of 0.093 mg/kg of toluene in sample L4-09. Based upon the sample results, the primary subsurface soil contamination at Site L appears to be centered in the pond. Limited subsurface soil contamination was detected east and west of the pond, at boring locations L1 and L4.

Many of the contaminants detected at Sites G, H, and I were detected in samples L2-03 and L3-04, including: 1,4-dichlorobenzene; naphthalene; methylnaphthalene; pentachlorophenol; and phenanthrene. Unlike Sites G, H, and I, Site L had no PCBs in subsurface soils.

Area 2

Subsurface soil samples from Site 0 in Area 2 revealed contamination in all but two borings. Individual samples from Site 0 contained 0.4%, 0.3%, and 0.05% organic contaminants. The level of contamination at Site 0 was lower than that of several samples from Sites G, H, and I, but higher than that of any sample from Site L.

Site 0. Samples from borings 04, 09, and 010 all exhibited substantial organic contamination. Samples from borings 09 and 010 exhibited higher levels of contamination in shallow samples (0 to 10-foot depth) than in deeper samples (10 to 20-foot depth). Similarly, the highest level of contamination of all Site 0 samples was detected in sample 04-62 from a depth of 0 to 10 feet. Samples from borings 04, 09, and 010 had many common contaminants such as, Aroclor 1242; pentachlorophenol; pyrene; chrysene; phenanthrene; 1,2-dichlorobenzene; chlorobenzene; ethylbenzene; and xylenes. Many of these contaminants were also detected in subsurface samples from Sites G, H, and I. Samples from borings 02, 03, and 05 contained limited contamination relative to borings 04, 09, and 010. Subsurface soil samples from borings 02, 03, and 05 from 20 to 30 feet, 10 to 20 feet, and 8 to 20 feet, respectively. Samples from off-site borings 01 and 06, which contained no detected contamination, were from 15 to 25 feet.

The sampling results indicate that the heaviest contamination at Site 0 is in the north-central portion of the site, although heavy contamination also exists in the eastern half of the site.

Although both samples from boring 05 contained limited detected HSL contaminants, the analyses indicated high concentrations of tentatively identified compounds (TICs). These TICs consisted of numerous substituted aromatic compounds such as 1-methyldecylbenzene and 1-pentylheptylbenzene, indicating the presence of contamination in the south-central portion of the site.

Sample analysis results, along with HNu field sample monitoring results, indicate lower subsurface soil contamination in the western portion of the site. Although, because of the limited number of borings and samples taken at the site, substantial contamination may exist in this area.

Peripheral Sites

Site J. Analysis of the soil from boring J2, on the east side of the site, shows substantial contamination by volatile and semivolatile organic contaminants. Ethylbenzene, xylenes, acenaphthene, dibenzofuran, fluorene, and phenanthrene were detected. Soil from boring J3, near the pit southeast of the Sterling Steel Foundry, shows low levels of dichlorobenzene and Aroclor 1260 in the sample from 0 to 10 feet deep. These samples showed different contaminants, although many of the compounds detected were also detected at Site I and other sites. Soil collected from between 10 and 20 feet deep in boring J1, in the northern portion of the site, showed no contamination.

The most highly contaminated soils at Site J were found in soils collected from between 15 and 25 feet at boring J2. The concentration of total organics detected in J2 was at a substantially lower concentration than the highest values found in samples from Sites G, H, I, L, and O.

Site K. Samples from borings K1, K2, and K3 show contamination with organic compounds. Analysis of the soil samples collected from borings K1 and K2 between 0 and 10 feet indicate contamination by several semivolatile compounds, including benzo(a)anthracene (0.94J and 0.9 mg/kg); chrysene (1.0J and 0.9 mg/kg); benzo(b)fluoranthene (1.0 and 1.2 mg/kg); and benzo(a)pyrene (0.93J and 0.94 mg/kg), respectively. The sample collected between 10 and 20 feet at boring K3 also showed semivolatile contamination, but at lower concentrations (e.g., benzo(a)anthracene at 0.35 mg/kg and benzo(a)pyrene at 0.6 mg/kg). The results of the analyses indicate fairly even and widespread semivolatile contamination across the site. Concentrations, while substantial, were lower than the high values at Sites G, H, I, and O.

Analysis of the soil samples also indicated that PCB contamination is present at all three borings. Borings K1 and K2 show Aroclor 1248 at 120 mg/kg and 4.8 mg/kg, respectively; K2 also shows Aroclor 1260 at 6.3 mg/kg; and K3 also shows Aroclor 1242 at 19 mg/kg.

All subsurface soil samples from K1 show cyanide contamination in soils between 0 and 10 feet, and K3 shows elevated tin levels in soils between 10 and 20 feet compared to background soil sample concentrations.

Site N. Soil samples from borings N1 and N2 had the same semi-volatile compounds as detected in subsurface soil samples at Sites H, I, K, and L. The shallow soils in the pit located at the northwest corner of the site are contaminated at levels lower than detected in the Site K borings. Borings N1 and N2 show contamination with compounds such as benzo(b)fluoranthene (0.29J mg/kg and 0.15J mg/kg respectively); pyrene (0.55 mg/kg and 0.22J mg/kg); and phenanthrene (0.43 mg/kg and 0.20J mg/kg). In addition, boring N1 (0 to 10 feet) shows contamination with benzo(a)anthracene (0.26J mg/kg); chrysene (0.28J mg/kg); and benzo(a)pyrene (0.21J mg/kg). These compounds were not detected in soil from boring N2 (5 to 15 feet). However, soils from boring N2 did show mercury levels elevated above background, while mercury was not detected in soils from boring N1. Neither boring N1 nor boring N2 reflected contamination by volatile organic compounds, pesticides, or PCBs.

Site P. The majority of subsurface soil contamination at Site P was confined to boring P1. Analyses of the sample taken from boring P1 revealed volatile and lighter-fraction semivolatile contamination. Two volatiles were detected in boring P2. No other organic contamination was detected at the site. This may have been partially because the P1 sample was collected from shallow (0-10 feet) soils, whereas samples from borings P2 and P5 were collected from greater depths (10 to 35 feet). Soils in the eastern portion of the site are contaminated with semivolatile and volatile organic compounds, but the contamination decreases with depth. Many of the contaminants detected in boring P1 were also detected at Sites G, H, I, L, and O.

None of the soil samples taken at Site P indicated contamination by pesticides or PCBs.

Soils from between 10 and 25 feet at the southwest corner of Site P (sample P5-55) show lead concentrations five to ten times higher than background. Elevated cyanide levels were also detected in soils from between 10 and 25 feet in the southwest corner (sample P5-55), and between 25 and 35 feet in the eastern portion of the site (sample P2-54).

4.2.5 Groundwater Sampling

Groundwater sampling was conducted at Sites G, H, I, L, O, Q, and R, and at five private wells in the study area.

4.2.5.1 Results

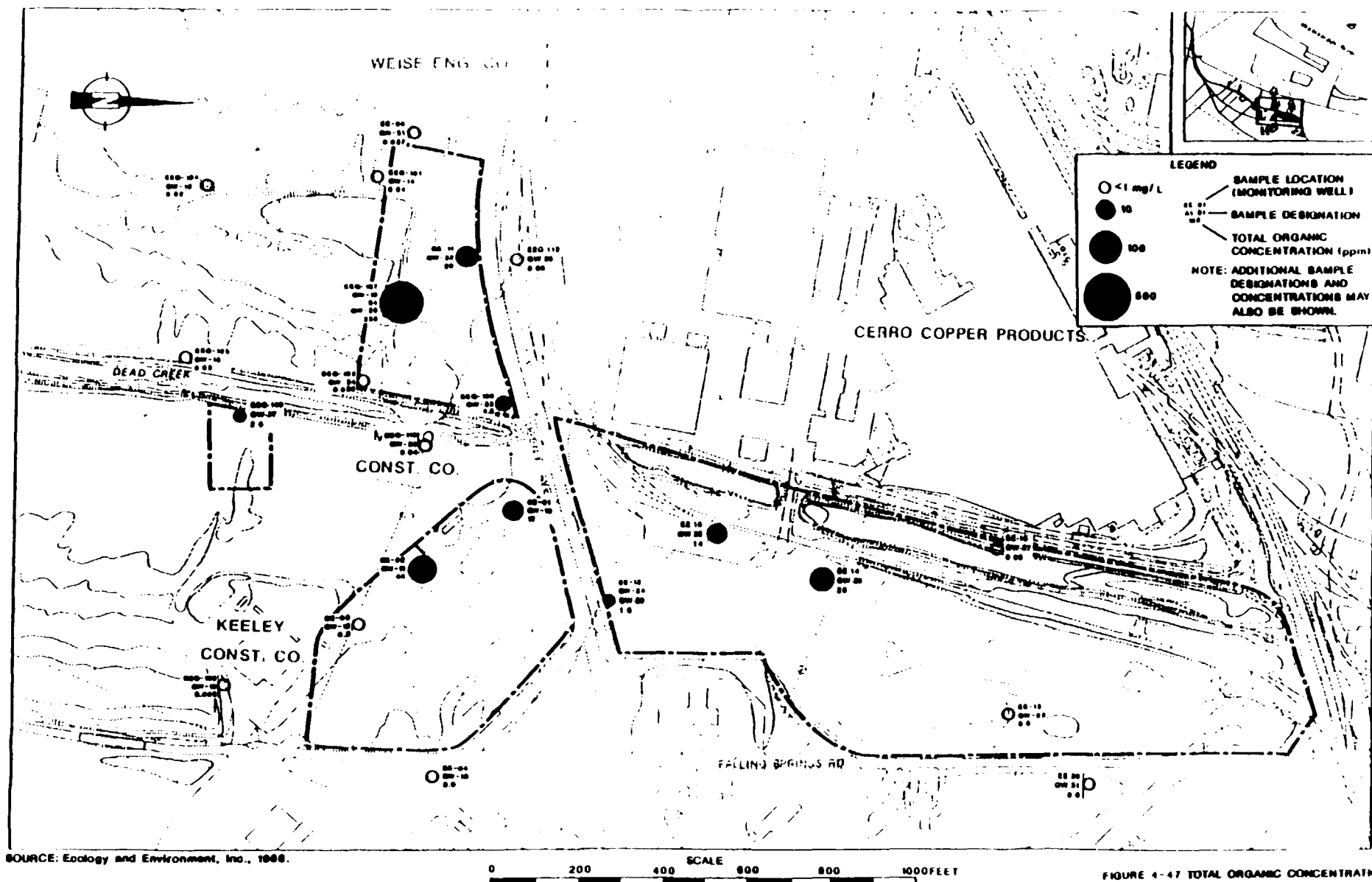
Results of the groundwater sampling and analysis are shown in Figures 4-47, 4-48 and 4-49, and Tables 4-20, 4-21, 4-22, 4-23, 4-24, and 4-25. Complete analytical data are provided in Appendix D.

Area 1

The groundwater sample results discussed below are based upon the samples collected from monitoring wells on March 17, March 18, and March 24, 1987, with the exception of sample GW-34A which was collected on July 14, 1987. The collection of sample GW-34A on July 14, 1987 at well EE-G102 was necessary because of accidental destruction of semivolatile and pesticide/PCB sample bottles of sample GW-34 collected March 24, 1987.

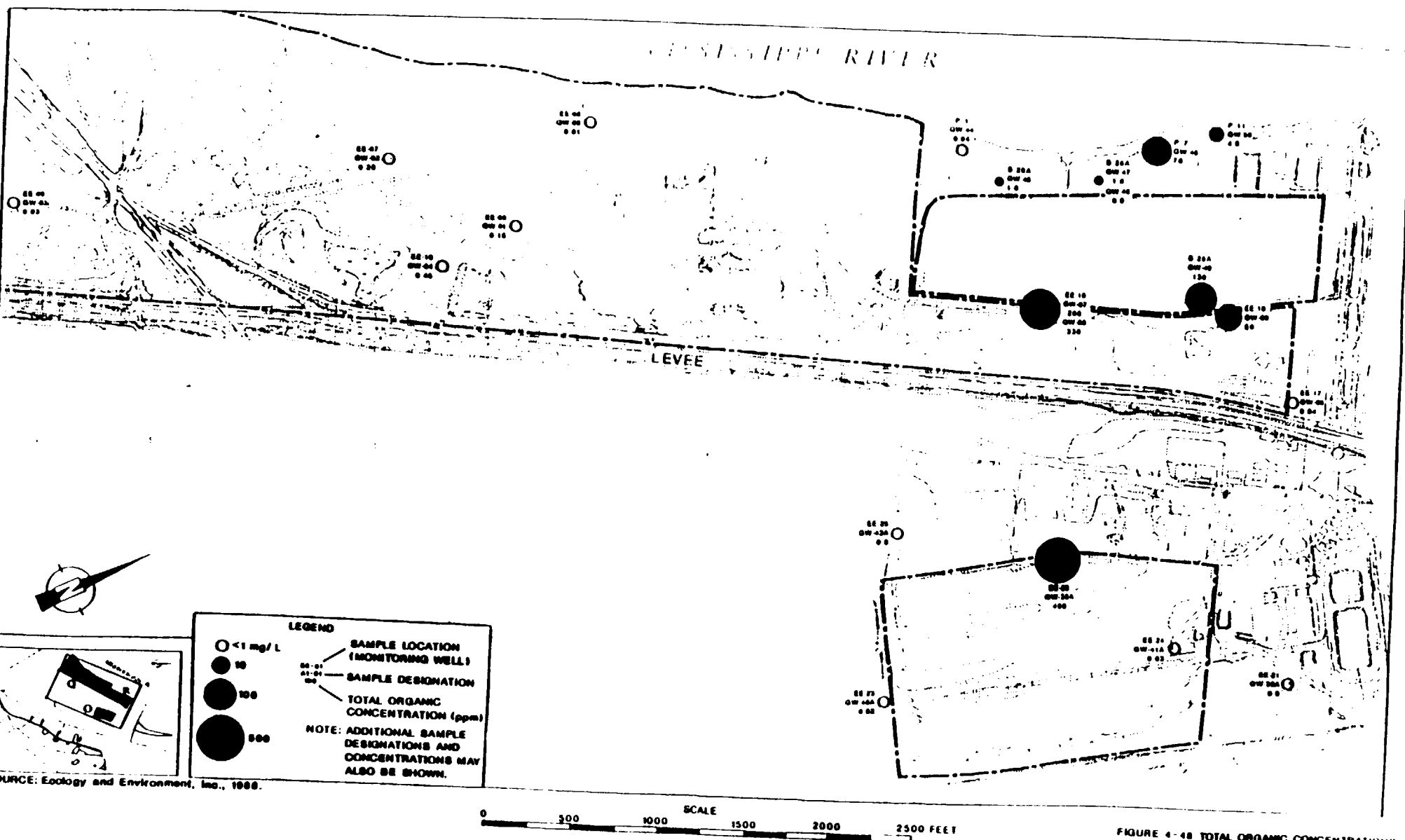
Site G

Volatile Organics. Analysis of the nine samples of groundwater from eight monitoring wells located on or around Site G revealed a total of 13 volatiles. All field samples contained at least one detected volatile contaminant. Sample GW-19 and duplicate sample GW-20 contained eleven and nine detected volatiles, respectively. Sample GW-33 contained seven volatiles, and sample GW-32 contained five volatiles. The highest concentration of any volatile contaminant detected was 7.3 mg/L of toluene in sample GW-19. Chlorobenzene, the most frequently detected volatile, was detected in seven samples.



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 4-47 TOTAL ORGANIC CONCENTRATIONS IN GROUNDWATER AT AREA 1



SOURCE: Ecology and Environment, Inc., 1988.

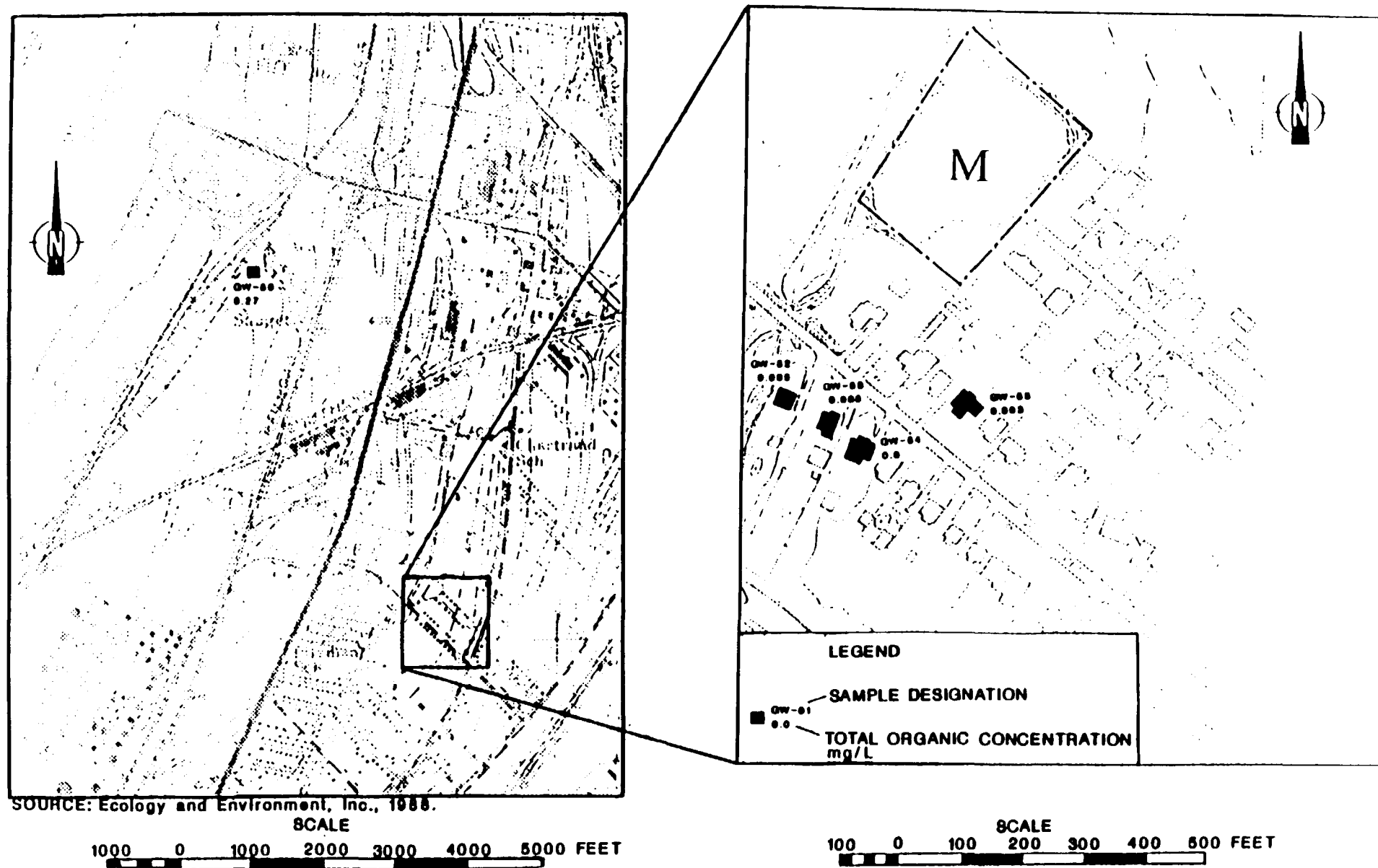


FIGURE 4-49 TOTAL ORGANIC CONCENTRATION IN RESIDENTIAL WELLS IN THE DCP AREA

Table 4-20

SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR SITE G

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
toluene	4	7.3	GW-19
benzene	4	4.1	GW-19
chlorobenzene	7	3.1	GW-19, GW-20
4-methyl-2-pentanone	3	2.2	GW-20
1,2-dichloroethane	2	0.48	GW-19
xylene	3	0.4	GW-32
ethylbenzene	2	0.84	GW-32
trans-1,2-dichloroethene	3	0.2J	GW-20
trichloroethene	3	0.8	GW-33
1,1,1-trichloroethane	1	0.051J	GW-33
tetrachloroethene	3	0.42	GW-19
<u>Semivolatile Organics</u>			
benzoic acid	2	150E	GW-20
phenol	3	30	GW-20
naphthalene	5	21E	GW-19
4-chloroaniline	2	15E	GW-32
2-chlorophenol	4	1.9	GW-20
benzyl alcohol	2	8.6	GW-20
4-methylphenol	3	9.0	GW-20
2,4-dimethylphenol	3	4.3	GW-20
bis-(2-chloroethoxy)methane	2	7.3	GW-20
1,2,4-trichlorobenzene	3	1.9	GW-19

Table 4-20, (Cont.)

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
2,4,6-trichlorophenol	2	0.35	GW-20
2,4-dichlorophenol	3	0.48J	GW-19
pentachlorophenol	3	6.3	GW-20
hexachlorobenzene	1	0.006J	GW-21
benzo(a)anthracene	1	0.032	GW-14
1,4-dichlorobenzene	4	0.57	GW-19
1,2-dichlorobenzene	3	0.2J	GW-19
<u>Pesticides/PCBs</u>			
Arochlor 1260	3	0.89	GW-19

* A total of 9 groundwater samples were collected from Site G. The numbers listed represent the number of samples, of the total of 9, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

E Estimated value. Amount detected in sample exceeds calibrated range.

Source: Ecology and Environment, Inc. 1988.

Table 4-21

SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR SITE H

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Number of Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	4	11	GW-11
toluene	2	7.3	GW-11
benzene	4	4.3	GW-11
4-methyl-2-pentanone	2	3.6	GW-11
chloroform	1	3.0	GW-11
ethylbenzene	2	0.21	GW-10
xylene	2	0.123	GW-11
<u>Semivolatile Organics</u>			
4-chloroaniline	4	6.4E	GW-10
benzoic acid	2	5.8E	GW-11
1,4-dichlorobenzene	3	2.6	GW-10
2,4-dichlorophenol	1	1.9	GW-11
2,4,6-trichlorophenol	2	1.2	GW-11
pentachlorophenol	1	0.65	GW-10
2,4,5-trichlorophenol	2	0.583	GW-11
phenol	2	0.95	GW-11
1,2,4-trichlorobenzene	2	0.72	GW-11
1,2-dichlorobenzene	3	0.56	GW-10
4-methylphenol	2	0.62	GW-11
2,4-dimethylphenol	1	0.33	GW-11
naphthalene	1	0.25	GW-10
dibenzofuran	1	0.0063	GW-10

Table 4-21, (Cont.)

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/L)	Sample Number of Highest Concentration
<u>Pesticides/PCBs</u>			
Aroclor 1260	1	0.052	GW-10

^a A total of 5 groundwater samples were collected from Site H. The numbers listed represent the number of samples, of the total of 5, in which each compound was detected.

E Estimated value. Amount detected in sample exceeds calibrated range.

J Estimated value. Result is greater than zero, but less than specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 4-22

SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR SITE I

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	6	3.1	GW-26
benzene	6	1.4	GW-26
vinyl chloride	4	0.79	GW-28
toluene	3	0.74	GW-28
trans-1,2-dichloroethene	3	0.64	GW-28
ethylbenzene	4	0.19	GW-26
tetrachloroethene	1	0.47	GW-26
trichloroethene	2	0.27	GW-26
4-methyl-2-pentanone	1	0.23J	GW-26
1,1-dichloroethane	1	0.12	GW-27
<u>Semivolatile Organics</u>			
4-chloroaniline	6	9.6E	GW-28
bis-(2-chloromethoxy)methane	2	2.9	GW-26
1,2,4-trichlorobenzene	1	2.7	GW-26
pentachlorophenol	4	2.4	GW-26
phenol	2	1.8	GW-26
2,4-dichlorophenol	2	1.0	GW-26
1,4-dichlorobenzene	5	0.91	GW-26
2-chlorophenol	2	0.37	GW-26
benzyl alcohol	2	0.35	GW-28
2,4,6-trichlorophenol	1	0.29	GW-26

Table 4-22 (Cont.)

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/kg)	Sample Containing Highest Concentration
naphthalene	2	0.23	GW-28
1,2-dichlorobenzene	5	0.22J	GW-26
1,3-dichlorobenzene	2	0.11	GW-24, GW-29
<u>Pesticides/PCBs</u>			
None detected			

^a A total of 8 groundwater samples were collected from Site I. The numbers listed represent the number of samples, of the total of 8, in which each compound was detected.

E Estimated value. Amount detected in sample exceeds calibrated range.

J Estimated value. Result is greater than zero, but less than specified detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 4-23

SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR SITE O

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	2	180E	GW-39A
benzene	2	150E	GW-39A
trichloroethene	1	64E	GW-39A
2-butanone	1	54E	GW-39A
acetone	1	34	GW-39A
methylene chloride	1	31	GW-39A
4-methyl-2-pentanone	1	28	GW-39A
trans-1,2-dichloroethene	1	14	GW-39A
1,1,2,2-tetrachloroethane	1	12	GW-39A
1,1,1-trichloroethane	1	5	GW-39A
toluene	2	1.3	GW-39A
<u>Semivolatile Organics</u>			
1,4-dichlorobenzene	1	15E	GW-39A
1,2-dichlorobenzene	1	11E	GW-39A
4-methylphenol	1	1.1	GW-39A
phenol	1	1.1	GW-39A
2,4-dimethylphenol	1	0.4	GW-39A
1,3-dichlorobenzene	1	0.29	GW-39A
1,2,4-trichlorobenzene	1	0.2	GW-39A
2-methylphenol	1	0.12	GW-39A

Table 4-23 (Cont.)

Chemical Name	Number of Times Detected ^a	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
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Pesticides/PCBs

None detected

^a A total of 5 groundwater samples were collected from Site O. The numbers listed represent the number of samples, of the total of 5, in which each compound was detected.

^E Estimated value. Amount detected in sample exceeds calibrated range.

Source: Ecology and Environment, Inc. 1988.

Table 4-24

SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR SITE Q

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
chlorobenzene	9	6.7J	GW-09
2-hexanone	2	3.5J	GW-09
1,2-dichloromethane	1	3.0	GW-09
4-methyl-2-pentanone	3	2.7J	GW-09
benzene	9	2.0	GW-07, GW-08, GW-09
toluene	4	1.6J	GW-09
xylenes	4	0.23	GW-02
ethylbenzene	3	0.33J	GW-07
<u>Semivolatile Organics</u>			
phenol	3	190E	GW-08
pentachlorophenol	3	35E	GW-08
2-chlorophenol	4	33E	GW-08
4-methylphenol	3	23E	GW-08
4-chloroaniline	4	15E	GW-08
2,4-dichlorophenol	3	14E	GW-08
2,4,6-trichlorophenol	3	6	GW-08
3-nitroaniline	2	3.9	GW-07
2,4-dimethylphenol	3	2.8	GW-08
2-nitroaniline	3	2.0	GW-09
1,2-dichlorobenzene	3	2.0	GW-09
nitrobenzene	2	0.82	GW-09
benzoic acid	2	0.6	GW-09
1,4-dichlorobenzene	4	0.25	GW-08

Table 4-24 (Cont.)

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Pesticides/PCBs</u>			

None detected

* A total of 9 groundwater samples were collected from Site Q. The numbers listed represent the number of samples, of the total of 9, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

E Estimated value. Amount detected in sample exceeds calibrated range.

Source: Ecology and Environment, Inc. 1988.

Table 4-25

SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR SITE R

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Volatile Organics</u>			
1,2-dichloroethane	1	16	GW-49
chlorobenzene	7	8.1	GW-49
benzene	5	1.5	GW-46
toluene	4	0.76J	GW-49
xylenes	2	0.95J	GW-46
<u>Semivolatile Organics</u>			
phenol	2	60E	GW-49
4-chloroaniline	4	25E	GW-46
2-chlorophenol	6	14E	GW-49
2,4-dichlorophenol	2	14E	GW-49
benzoic acid	2	6.8	GW-49
4-methylphenol	2	6.1	GW-49
2,4,6-trichlorophenol	2	2.1	GW-46
hexachloroethane	1	0.85	GW-46
benzyl alcohol	1	0.75	GW-46
1,4-dichlorobenzene	4	0.55	GW-46
nitrobenzene	3	0.42	GW-49
1,2-dichlorobenzene	4	0.34	GW-46

Table 4-25 (Cont.)

Chemical Name	Number of Times Detected*	Highest Concentration Detected (mg/L)	Sample Containing Highest Concentration
<u>Pesticides/PCBs</u>			
None detected			

* A total of 7 groundwater samples were collected from Site R. The numbers listed represent the number of samples, of the total of 7, in which each compound was detected.

J Estimated value. Result is greater than zero, but less than specified detection limit.

K Estimated value. Amount detected in sample exceeds calibrated range.

Source: Ecology and Environment, Inc. 1988.

Semivolatile Organics. Analysis of the nine samples of groundwater from eight monitoring wells located on or around Site G revealed a total of 20 semivolatiles. At least one semivolatile contaminant was detected in six of the samples. Duplicate samples GW-19 and GW-20 contained 14 and 15 detected volatiles, respectively. Sample GW-33 contained nine semivolatiles, and sample GW-32 contained six semivolatiles. The highest concentration of any semivolatile contaminant detected was 150E ug/L of benzoic acid in sample GW-20. Naphthalene, the most frequently detected semivolatile, was detected in five samples.

Pesticides/PCBs. Analysis of the nine samples of groundwater from eight monitoring wells on or around at Site G revealed one PCB congener, Aroclor 1260, and no pesticides. Aroclor 1260 was detected in three samples from two monitoring wells. The highest concentration of Aroclor 1260 was detected in sample GW-19, which contained 0.89 mg/L.

Inorganics. Analysis of the nine samples of groundwater from eight monitoring wells on or around Site G revealed elevated concentrations of antimony, arsenic, cadmium, chromium, cobalt, mercury, nickel, vanadium, zinc, and cyanide compared to background groundwater concentrations.

Site H

Volatile Organics. Analysis of the five groundwater samples collected from five monitoring wells on or around Site H revealed a total of seven volatiles. Volatiles were detected in each groundwater sample from Site H, with the exception of GW-13. Samples GW-10 and GW-11 each contained six volatile organics. The highest concentration was 11 mg/L of chlorobenzene in sample GW-11. Chlorobenzene and benzene, the most frequently detected volatile at Site H, were detected in four of the five samples.

Semivolatile Organics. Analysis of the five groundwater samples from five monitoring wells on or around Site H revealed a total of 24 semivolatiles. Semivolatiles were detected in each groundwater sample from Site H except GW-13. Sample GW-10 contained 19 semivolatiles and sample GW-11 contained 18. The highest concentration was 6.4E mg/L of

4-chloroaniline in sample GW-10. The most frequently detected semi-volatile was 4-chloroaniline, which was detected in four samples at Site H.

Pesticides/PCBs. Analysis of the five samples of groundwater from five monitoring wells on or around Site H revealed one PCB congener, Aroclor 1260, and no pesticides. Aroclor-1260 was detected in one sample, GW-10, at a concentration of 0.052 mg/L.

Inorganics. Analysis of the five samples of groundwater from five monitoring wells on or around Site H revealed elevated concentrations of aluminum, arsenic, cadmium, chromium, cobalt, copper, lead, nickel, zinc, and cyanide, compared to background groundwater concentrations.

Site I

Volatile Organics. Analysis of the eight samples of groundwater from seven monitoring wells at Site I revealed a total of 13 volatiles. At least one volatile contaminant was detected in each sample, except samples GW-23 and GW-31. Sample GW-29 is a duplicate of sample GW-24. Sample GW-26 contained 10 detected volatile contaminants, and sample GW-27 and GW-28 each contained seven. The highest concentration of any volatile contaminant detected was 3.1 mg/L of chlorobenzene in sample GW-26. Chlorobenzene and benzene, the most frequently detected volatiles, were detected in six samples.

Semivolatile Organics. Analysis of the eight samples of groundwater from seven monitoring wells at Site I revealed a total of 19 semivolatiles. Six of the eight field samples contained at least one semivolatile. Samples GW-23 and GW-31 contained no semivolatiles. Sample GW-26 contained 15 semivolatiles, the greatest number detected in any sample. Sample GW-28 contained the highest concentration of any detected semivolatile, 9.6E mg/L of 4-chloroaniline. Sample GW-26 contained 8.3 mg/L of 4-chloroaniline. The semivolatile 4-chloroaniline was also the most frequently detected contaminant. It was detected in six of the eight samples. The semivolatiles 1,2-dichlorobenzene and 1,4-dichlorobenzene were each detected in five field samples.

Pesticides/PCBs. No pesticides or PCBs were detected in any of the Site I groundwater samples.

Inorganics. Analysis of the eight samples of groundwater from seven monitoring wells at Site I revealed elevated concentrations of arsenic, barium, and nickel compared to background groundwater concentrations.

Site L

Volatile Organics. Analysis of the one sample (GW-37) of groundwater from the monitoring well at Site L revealed a total of four volatiles. The highest concentration of any volatile contaminant detected was 0.978 mg/L of toluene. Chloroform was detected at a concentration of 0.73 mg/L.

Semivolatile Organics. Analysis of the one sample of groundwater from the monitoring well at Site L revealed a total of six semivolatiles. The highest concentrations of any semivolatiles detected were for phenol and 2-chlorophenol, which were both detected at 0.15 mg/L. The next highest concentrations were 0.075 mg/L of 4-methylphenol and 0.06 mg/L of 4-chloroaniline.

Pesticides/PCBs. No pesticides or PCBs were detected in the Site L groundwater sample.

Inorganics. Analysis of the one sample of groundwater from the monitoring well at Site L revealed elevated concentrations of arsenic, cadmium, cobalt, vanadium, and zinc compared to background groundwater concentrations.

Area 2

Site 0

There were two groundwater sampling rounds for Site 0. The analyses of the first round samples were only partially performed due to the accidental destruction of several of the samples. The discussion below

is based upon the results of the analyses of the second sampling round conducted on July 14, 1987, which complete analyses were performed for all samples.

Volatile Organics. Analysis of the five samples of groundwater from five monitoring wells at Site 0 revealed a total of 16 volatiles. Sample GW-39A contained 16 detected volatiles. Sample GW-41A contained two volatiles and GW-40A contained one. The highest concentration was 180E mg/L of chlorobenzene in GW-39A. Chlorobenzene and benzene were detected in GW-41A. Toluene was detected in GW-40A. No volatiles were detected in GW-38A or GW-43A.

Semivolatile Organics. Analysis of the five samples of groundwater from five monitoring wells at Site 0 revealed 11 semivolatiles. Only sample GW-39A contained semivolatiles. The highest concentration was 15E mg/L of 1,4-dichlorobenzene. The contaminant 1,2-dichlorobenzene was detected at a concentration of 11E mg/L.

Pesticides/PCBs. No pesticides or PCBs were detected in any groundwater samples from Site 0.

Inorganics. Analysis of the five samples of groundwater from five monitoring wells at Site 0 revealed elevated concentrations of arsenic, cadmium, lead, and vanadium compared to background groundwater concentrations.

Site 0

Volatile Organics. Analysis of the nine samples of groundwater from eight monitoring wells at Site 0 revealed a total of 11 volatiles. All samples contained at least one volatile contaminant. Sample GW-09 contained six detected volatiles, as did sample GW-07 and duplicate sample GW-08. The highest concentration detected was 6.7J mg/L of chlorobenzene in sample GW-09. Chlorobenzene and benzene, the most frequently detected volatiles, were detected in all nine field samples.

Semivolatile Organics. Analysis of the nine samples of groundwater from monitoring wells at Site Q revealed a total of 20 semivolatiles. At least one semivolatile contaminant was detected in six of the nine samples. Samples GW-03, GW-05, and GW-06 contained no semivolatiles. Sample GW-09 contained 19 semivolatiles, and samples GW-08 and GW-07 contained 15 and 14, respectively. The highest concentration was 190E mg/L of phenol in sample GW-08. The next highest was 35E mg/L of pentachlorophenol in sample GW-08. The semivolatiles 2-chlorophenol; 1,4-dichlorobenzene; and 4-chloroaniline were detected most frequently (4 times).

Pesticides/PCBs. No pesticides or PCBs were detected in any of the nine groundwater samples from Site Q.

Inorganics. Analysis of the nine samples of groundwater from eight monitoring wells at Site Q revealed elevated concentrations of arsenic, chromium, cobalt, nickel, and cyanide compared to background groundwater concentrations.

Site R

Volatile Organics. Analysis of the seven samples of groundwater from six monitoring wells at Site R revealed a total of eight volatiles. Sample GW-42 is a duplicate of sample GW-41. All samples contained at least one volatile contaminant. Sample GW-47 contained seven. Sample GW-49, which had three volatiles, contained the highest concentration, 16 mg/L of 1,2-dichloroethane. Chlorobenzene was the only volatile detected in all samples from Site R.

Semivolatile Organics. Analysis of the seven samples of groundwater from six monitoring wells at Site R revealed a total of 15 semivolatiles. At least one semivolatile contaminant was detected in each of the samples. Sample GW-46 contained 13, and sample GW-49 contained nine. The highest concentration was 60E mg/L of phenol in sample GW-49. The semivolatile 4-chloroaniline was the next highest concentration, with 25E mg/L in sample GW-46. The most frequently detected semivolatile was 2-chlorophenol, which was detected in each sample except GW-50.

Pesticides/PCBs. No pesticides or PCBs were detected in any of the groundwater samples from Site R.

Inorganics. Analysis of the seven samples of groundwater from monitoring wells at Site R revealed elevated concentrations of arsenic, cobalt, nickel, vanadium, and cyanide compared to background groundwater concentrations.

Peripheral sites

The results of analyses of samples collected from the five private wells shown in Figure 3-15 are presented below.

Volatile Organics. Analysis of each of the five private well groundwater samples revealed a total of 11 volatiles. Sample GW-52 contained two volatiles, toluene (0.001BJ mg/L) and ethylbenzene (0.004J mg/L). Sample GW-53 contained four including carbon disulfide (0.003J mg/L) and styrene (0.002J mg/L). Sample GW-55 contained two volatiles, toluene (1BJ mg/L) and styrene (0.002J mg/L). Sample GW-56 contained eight volatiles including chlorobenzene (0.12 mg/L), benzene (0.094 mg/L), and vinyl chloride (0.017 mg/L). No volatiles were detected in sample GW-54. Toluene was detected in four of the five private wells.

Semivolatile Organics. Analysis of each of the five private well groundwater samples revealed semivolatiles in only one sample, GW-56. The semivolatiles 1,4-dichlorobenzene and 1,2-dichlorobenzene were detected at concentrations of 0.005J mg/L and 0.003J mg/L, respectively.

Pesticides/PCBs. No pesticides or PCBs were detected in any of the private well groundwater samples.

Inorganics. Analysis of each of the five private well groundwater samples revealed elevated concentrations of arsenic, copper, lead, and mercury compared to background groundwater concentrations.

4.2.5.2 Discussion

Area 1

Examination of the results of the groundwater sampling of monitoring wells at Sites G, H, I, and L revealed groundwater contamination at each of the sites. Sites G, H, and I each had at least one well that exhibited extremely elevated volatile and semivolatile organic contaminants compared to other contaminated wells at the same site.

Site G. Groundwater samples collected at Site G exhibited substantial organic and inorganic contamination. The greatest amount of contamination was found near the center of the site at monitoring well EE-G107, where samples GW-19 and GW-20 were collected. Two other locations exhibited lower, but still substantial, groundwater contamination. Groundwater samples from monitoring wells EE-11 (GW-32), located centrally along the northern edge of Site G, and EE-G106 (GW-33), located in the northeast corner of Site G, exhibited substantial but lower contamination than groundwater from EE-G107. Groundwater samples from each of these monitoring wells had many of the same contaminants, namely, chlorobenzene, toluene, benzene, 2-chlorophenol, 1,4-dichlorobenzene, and 4-chloroaniline. Groundwater from monitoring well EE-G107 contained 14 contaminants also detected in subsurface soil sample G6-67 from the same location, including chlorobenzene, toluene, phenol, 4-chloroaniline, naphthalene, and Aroclor 1260. Groundwater from monitoring well EE-G106 contained benzene, chlorobenzene, and 1,4-dichlorobenzene, which had also been detected in subsurface soil samples from the same location, as well as numerous other contaminants. Similarly, groundwater from monitoring well EE-11 contained chlorobenzene and ethylbenzene, which were also detected in subsurface soil sample G3-33, from the same location, as well as numerous other contaminants. Groundwater from monitoring well EE-11 contained a substantial concentration of 4-chloroaniline (15E mg/L); this compound has also been detected in a nearby subsurface soil sample (G7-69) at 230J mg/kg. Results of groundwater sampling at Site G indicate that the area of the most concentrated groundwater contamination is the south central portion of the site, but organic and inorganic contamination is present

to a lesser degree at numerous other locations. The off-site monitoring wells EEG-101 (GW-14), EEG-103 (GW-15), EEG-104 (GW-16), and EEG 102 (GW-34), located to the south of Site G or on its southern perimeter, all showed some organic contamination.

Site H. Groundwater samples collected from monitoring wells at Site H were contaminated with numerous organic and inorganic contaminants, although generally at lower concentrations than at Site G. The greatest groundwater contamination was detected at monitoring well EE-02, where sample GW-11 was collected. Well EE-02 is located on the western edge of Site H, approximately halfway between well EE-01 to the northwest and well EE-03 to the southeast. Numerous contaminants were detected in sample GW-10 from well EE-03 at concentrations which were elevated compared to background levels. Groundwater collected from monitoring well EE-03 exhibited fewer and lower concentrations of contaminants than EE-02 and EE-01. Groundwater collected from monitoring well EE-G110, located west of Site H and east of the fenced-off area of Creek Sector B, exhibited still lower concentrations of contaminants. The three organic contaminants (4-chloroaniline, chlorobenzene, and benzene) and the inorganic contaminants (barium and nickel) present in groundwater sample GW-36 from monitoring well EE-G110 were also present in elevated concentrations in groundwater samples from EE-01 and EE-02. Groundwater collected from monitoring well EE-04, located east of Site H, exhibited no organic or inorganic contaminants. Organic contaminants detected in subsurface soil samples from borings H1, H2, H3 and H4, located at or near monitoring wells EE-01 and EE-02, exhibited many of the same contaminants as were detected in groundwater samples from these wells. Some of the contaminants detected in subsurface soils and associated groundwater included: chlorobenzene; toluene; benzene; 1,4-dichlorobenzene; 1,2-dichlorobenzene; 1,2,4-trichlorobenzene; 2,4,6-trichlorophenol; and Aroclor 1260. Many of these contaminants were also found in contaminated groundwater samples from Site G.

Site I. Groundwater samples from monitoring wells at Site I exhibited contamination in five of the seven wells. The greatest amount of groundwater contamination was in monitoring well EE-14, where sample

GW-26 was collected. Well EE-14 is located near the center of the site, just east of the railroad tracks. Numerous elevated concentrations of contaminants were detected in groundwater sample GW-28 from well EE-16. Well EE-16 is located east of the railroad tracks, approximately 400 feet south of well EE-14. Groundwater from monitoring wells EE-12 (located near the southeast corner of the site), and EE-15 (located on the west side of Dead Creek, approximately 400 feet north of EE-14) exhibited numerous contaminants at substantial concentrations. Groundwater from monitoring well EEG-112, southeast of site showed lower levels of contamination. Groundwater samples from monitoring wells EE-13 (GW-23), in the north-central portion of Site I, and EE-20 (GW-31), northeast of Site I, exhibited no organic contamination. Groundwater from EE-13 exhibited some inorganic contamination.

Numerous organic contaminants were present in all contaminated monitoring wells at Site I. These included: chlorobenzene; benzene; 1,4-dichlorobenzene; 1,2-dichlorobenzene; and 4-chloroaniline. In addition, many contaminants found in subsurface soils at Site I were also found in associated groundwater. Some of these contaminants were: toluene; ethylbenzene; 1,3-dichlorobenzene; phenol; naphthalene; 2-methylnaphthalene; and pentachlorophenol. Many of these contaminants were also found in groundwater at Sites G and H.

Site L. The groundwater sample GW-37 from monitoring well EE-G109 on the west edge of Site L exhibited organic and inorganic contamination. Many of the contaminants detected in the groundwater sample had also been found in Site L subsurface soil samples. These included: toluene; 4-methyl-2-pentanone; benzene; chloroform; phenol; 2-chlorophenol; 4-methylphenol; arsenic; cadmium; cobalt; and vanadium. Contaminant concentrations in the groundwater at Site L were lower than at Sites G, H, and I.

Area 2

Groundwater sampling at Sites O, Q, and R revealed volatile, semi-volatile, and inorganic contamination at each site. Neither pesticides nor PCBs were detected in groundwater samples from any of these sites.

Site O. Groundwater samples from Site O revealed substantial volatile, semivolatile, and inorganic contamination at monitoring well EE-22, on the western boundary of Site O, about midway between the northern and southern edge of the site. Limited volatile and inorganic contamination was detected in samples from wells EE-23 (GW-40A), along the southern edge of Site O, and EE-24 (GW-41A), near the northern edge. No contamination was identified in groundwater monitoring wells EE-21 and EE-25, located to the northeast and southeast of Site O, respectively.

Volatile and semivolatile contamination in groundwater from well EE-22 included many contaminants also detected in subsurface soil samples from the site. These contaminants included: trans-1,2-dichloroethane; benzene; 4-methyl-2-pentanone; toluene; chlorobenzene; ethylbenzene; xylenes; phenol; 1,2-dichlorobenzene; 1,2,4-trichlorobenzene; naphthalene; and arsenic. Groundwater sampling results indicate that contamination present in well EE-22 is resulting from materials buried to the east of the well on Site O. Buried contaminants are entering the groundwater and are moving westerly with the groundwater flow.

Site Q. Groundwater samples from all monitoring wells at Site Q exhibited contamination. The greatest amount of groundwater contamination was in the northern third of the site, at wells EE-18 (sample GW-09) and EE-19 (samples GW-07 and GW-08). Organic contaminant concentrations at these two wells were comparable to that of the most contaminated wells at Sites G, H, and O. Many of the organic contaminants in the groundwater at these wells had also been detected in subsurface soil from the northern portion of Site Q collected during the July 1983 FIT investigation. These contaminants included: 2,4,6-trichlorophenol; 2,4-dichlorophenol; pentachlorophenol; 1,2,4-trichlorobenzene; 1,2-dichlorobenzene; nitrobenzene; chlorobenzene; and 4-methylphenol. In addition, many contaminants found in groundwater at Site Q had also been found in groundwater at Sites G, H, I, and O. These included: chlorobenzene; 4-methyl-2-pentanone; benzene; phenol; pentachlorophenol; 4-chloroaniline; 2-chlorophenol; 2,4-dichlorophenol; arsenic; cobalt; and nickel. Although all other monitoring wells at

Site Q exhibited organic contamination, contaminants were fewer and concentrations were significantly lower in the other wells. The highest organic contaminant concentrations at the other monitoring wells were: 0.12 mg/L of 4-chloroaniline at EE-06 (GW-01); 0.23 mg/L of xylenes at EE-07 (GW-02); 0.033 mg/L of chlorobenzene at EE-09 (GW-03); 0.38E mg/L of chlorobenzene at EE-10 (GW-04); 0.029 mg/L of chlorobenzene at EE-17 (GW-05); and 0.07 mg/L of chlorobenzene at EE-08 (GW-06). The highest inorganic contaminant concentrations were arsenic in monitoring well EE-10 (0.1 mg/L) and cyanide in EE-06 (1.56 mg/L).

Site R. Groundwater samples from Site R exhibited substantial organic and inorganic (arsenic) contamination. The greatest amount of contamination was at monitoring well B-25A, near the eastern edge of the site about 600 feet south of the northern site boundary. However, contamination detected at monitoring well P7, along the western side of the site about midway between the northern and southern site boundaries, was of the same order of magnitude. Organic contaminants present in groundwater at monitoring wells B-25A and P7, and in lower concentrations in groundwater from other monitoring wells at Site R, reflected chemicals reported by Monsanto to have been disposed of at the site. Some of these chemicals/contaminants included: 2,4-dichlorophenol; 1,2-dichlorophenol; 1,4-dichlorophenol; 1,2-dichlorobenzene; 1,4-dichlorobenzene; phenol; 2-chlorophenol; chlorobenzene; and 4-chloroaniline. These and other contaminants had also been detected in leachate and sediment samples collected during previous investigations of the site by IEPA and USEPA. In addition, many of the contaminants present in groundwater at Site R were the same as in groundwater at Sites G, H, I, O, and Q. Although the four other monitoring wells at Site R also exhibited organic contamination, contaminants at the other wells were fewer and concentrations were significantly lower. The highest concentrations detected in the other wells ranged from 4.1 mg/L of 4-chloroaniline in well P-11 (GW-50) to 0.35E mg/L of chlorobenzene in well P-1 (GW-44). Arsenic was detected in groundwater samples from all monitoring wells on the west side of the site except well P-7 (GW-46). Cyanide was detected in groundwater from well P-11 (GW-50), at a concentration of 0.014 mg/L.

Peripheral Sites

Private well groundwater from four residential wells located along Judith Lane, just south of Site M, exhibited low-level organic contamination in three of the four well samples (GW-52, GW-53, and GW-55). Private well GW-54 exhibited no organic contamination, but did exhibit arsenic, copper, lead, and mercury contamination.

The fifth private well sampled was the Clayton Chemical Co. well (GW-56), west of Site O, about 200 feet northwest of monitoring well EE-22. Sample GW-56 exhibited 10 organic contaminants. Although the contamination in GW-56 was significantly lower than that in GW-39A, six of the 10 contaminants detected in GW-56 were very elevated in GW-39A. The difference in concentrations and contaminants present in these two wells is attributable to the large volume of daily pumpage which occurs at the Clayton Chemical Co. well and to the fact that the Clayton well is screened at a greater depth than EE-22. The contamination detected in GW-56 indicates that contamination originating at Site O is being transported off-site and contaminating groundwater used by the public.

4.2.6 Air Sampling

4.2.6.1 Introduction

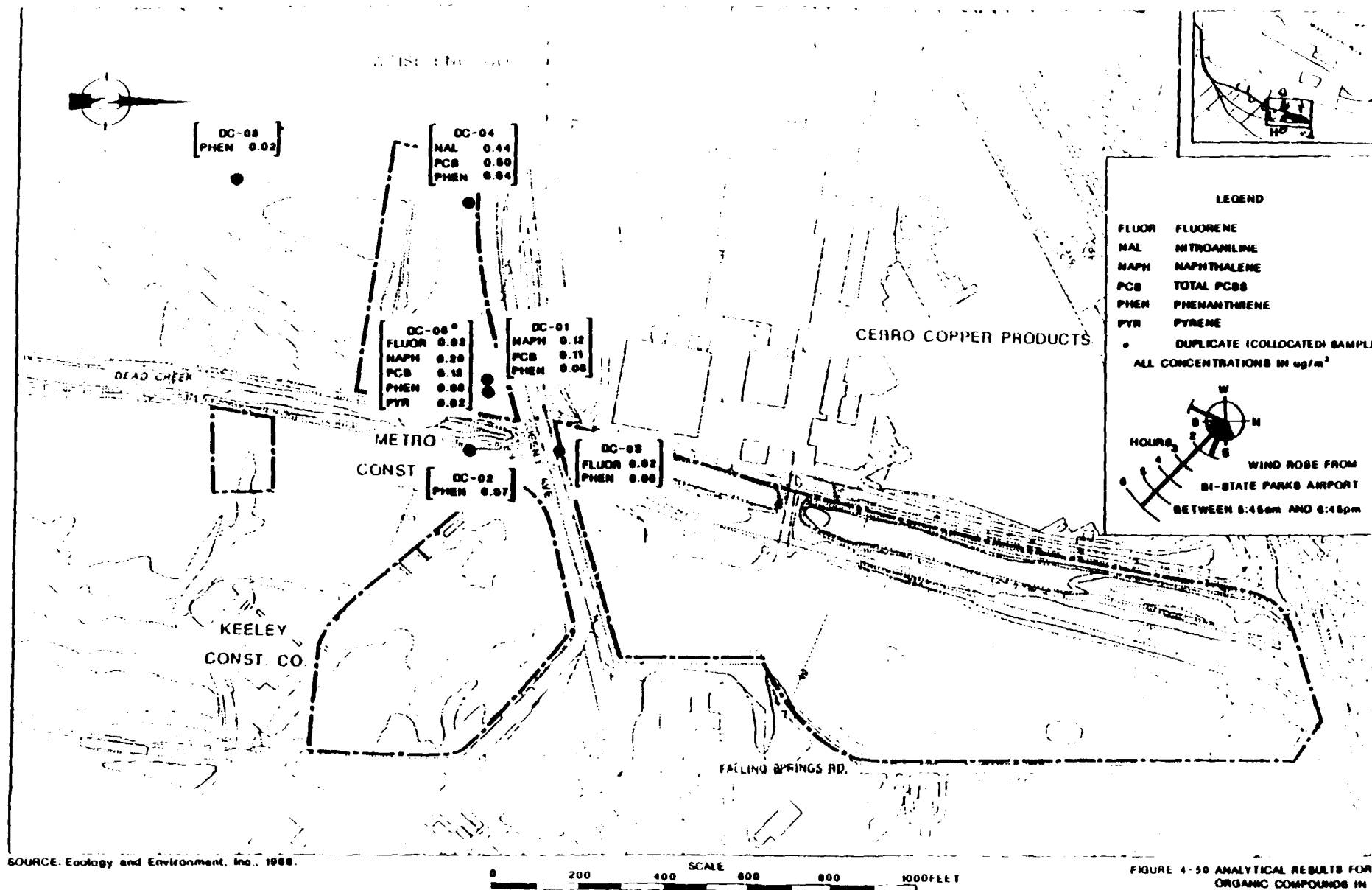
This section presents the analytical results of air samples collected in Area 1 around Site G and CS-B, and in Area 2 around Sites Q and R. Sampling was conducted on July 16 and July 17, 1987, at Area 1, and July 21 and July 22, 1987, at Area 2. Results are presented separately for each area sampled, and a discussion of the results follows the data summaries for each area.

4.2.6.2 Area 1 - Site G/CS-B

Results

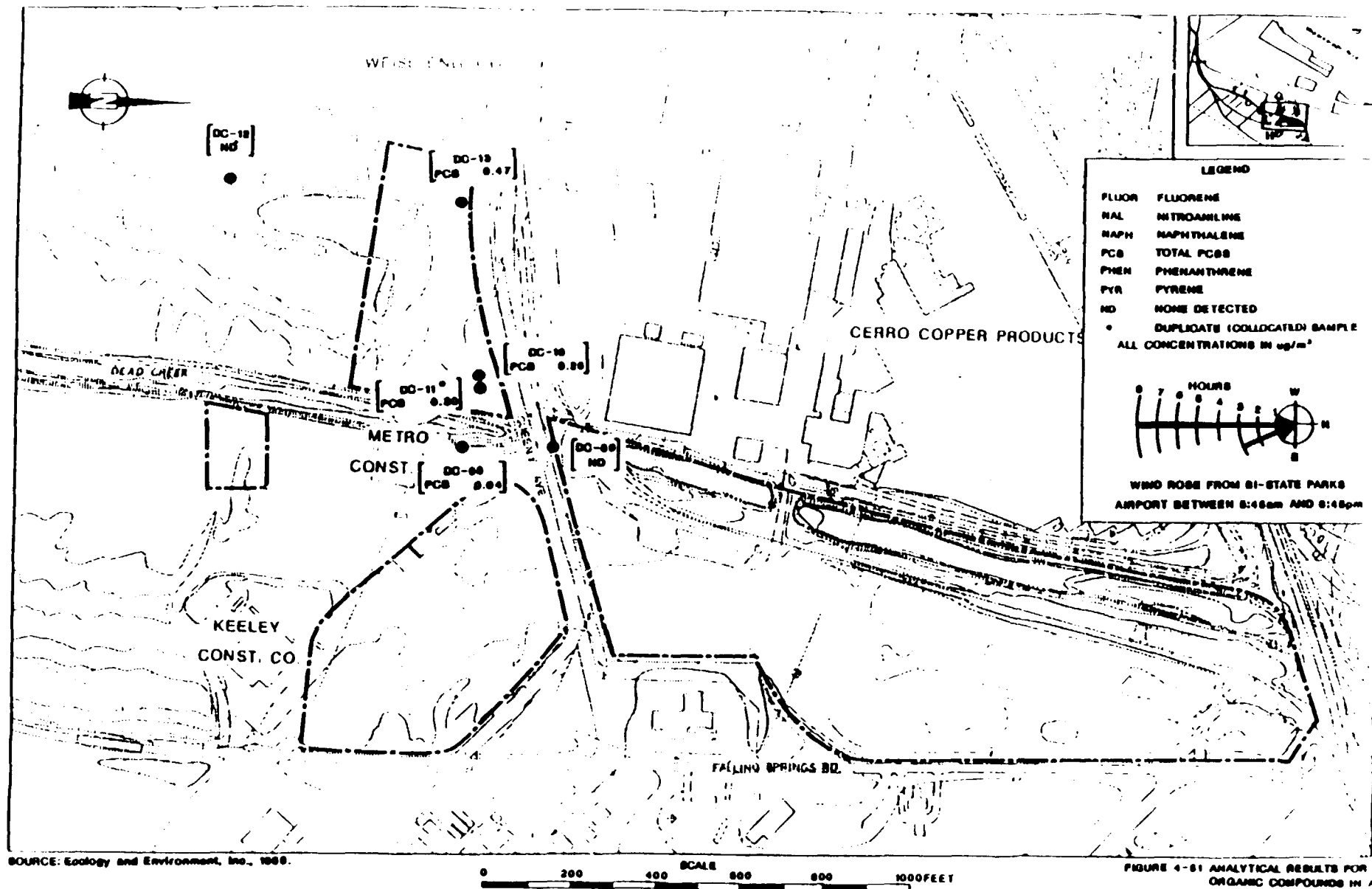
Analytical results for air sampling collected at Site G/CS-B are presented in Figures 4-50 and 4-51, and in Table 4-26.

Volatile Organics. With the exception of benzene, which was also found in the blank samples, no volatile organic compounds were detected for either day of sampling at Site G/CS-B.



SOURCE: Ecology and Environment, Inc., 1990.

FIGURE 4-50 ANALYTICAL RESULTS FOR SELECT ORGANIC COMPOUNDS IN AIR SAMPLES AT SITES Q AND C8-H ON JULY 10, 1990



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 4-81 ANALYTICAL RESULTS FOR SELECT ORGANIC COMPOUNDS IN AIR SAMPLES AT SITES G AND CB 8 ON JULY 17, 1987

Table 4-26

SUMMARY OF AIR SAMPLING RESULTS FOR SITE G/CS-B

Compound	Sample Number													
	DC-01†	DC-02	DC-03	DC-04	DC-05	DC-06†	DC-07*	DC-08	DC-09	DC-10†	DC-11†	DC-12	DC-13	DC-14*
benzene	74JB	80JB	63JB	NA	75JB	118JB	17JB	67JB	51JB	66JB	101JB	70JB	NA	15JB
naphthalene	0.12	--	--	--	--	0.20	--	--	--	--	--	--	--	--
phenanthrene	0.08J	0.07J	0.08J	0.04J	0.02J	0.08J	--	--	--	--	--	--	--	--
2-methylnaphthalene	--	--	0.03J	--	0.02J	0.02J	--	--	--	--	--	--	--	--
isophorone	--	--	--	--	0.02JB	0.01J	--	--	--	--	--	--	--	--
n-nitrosodiphenylamine	--	--	--	0.02J	0.02J	0.05J	--	--	--	--	--	--	--	--
fluorene	--	--	0.02J	--	--	0.02J	--	--	--	--	--	--	--	--
2-nitroaniline	--	--	--	0.44	--	--	--	--	--	--	--	--	--	--
benzyl alcohol	--	--	--	--	--	0.05J	--	--	--	--	--	--	--	--
fluoranthene	--	--	--	--	--	0.01J	--	--	--	--	--	--	--	--
pyrene	--	--	--	--	--	0.02J	--	--	--	--	--	--	--	--
Aroclor 1248	0.11	--	--	0.15	--	0.12	--	0.04	--	0.26	0.30	--	0.12	--
Aroclor 1254	--	--	--	0.18	--	--	--	--	--	--	--	--	0.18	--
Aroclor 1260	--	--	--	0.17	--	--	--	--	--	--	--	--	0.17	--
chromium	--	--	--	--	--	0.08	--	--	--	--	--	--	--	--
copper	0.94	0.67	0.66	0.71	0.35	0.73	--	0.87	0.78	0.62	0.76	0.38	0.67	--
lead	0.08	0.09	0.09	0.08	0.08	0.08	--	0.77	0.64	0.56	0.67	0.04	0.04	--
zinc	0.20	0.32	0.31	0.13	0.13	0.18	--	0.56	1.43	0.28	0.92	0.08	0.11	--

All results in $\mu\text{g}/\text{m}^3$.

Samples DC-01 through DC-07 collected 7/16/87. Samples DC-08 through DC-14 collected 7/17/87.

† Duplicate (collocated) samples.

* Blank samples - results reported in μg per sample medium (filter, cartridge).

J Indicates estimated value. Result is less than the specified detection limit, but greater than zero.

B Compound also found in blank sample.

NA Not analyzed.

-- Not detected.

Source: Ecology and Environment, Inc. 1988.

Semivolatile Organics. A total of 10 semivolatile compounds were detected in the seven samples collected on the initial day of sampling (samples DC-01 through DC-07). The background sample DC-05 contained four semivolatile compounds and sample DC-06 contained nine semivolatile compounds. Four semivolatile compounds, naphthalene, fluorene, 2-nitroaniline, and pyrene, were detected only in downwind samples, with the highest concentration being 0.44 ug/m^3 for 2-nitroaniline in sample DC-04. No semivolatile compounds were detected during the second day of sampling.

Pesticides and PCBs. PCBs were detected in three downwind samples on the first day of sampling, and in four downwind samples on the second day. Samples DC-04 and DC-13, collected from the same station location on consecutive days, contained three PCB congeners, including Aroclors 1248, 1254, and 1260. The highest concentration detected was 0.18 ug/m^3 for Aroclor 1254 in both DC-04 and DC-13. Aroclor 1248 was also detected in the collocated samples on each day of sampling (DC-01 and DC-06; DC-10 and DC-11). No pesticides were detected in any of the samples collected from Site G/CS-B.

Inorganics. Three heavy metals, lead, copper, and zinc, were detected at similar concentrations in all samples except the blanks, with the highest concentration being 1.43 ug/m^3 for zinc in sample DC-09.

Discussion

Examination of the analytical results of air sampling conducted at Area 1 indicates a documentable release of several contaminants, including PCBs, naphthalene, 2-nitroaniline, fluorene, and pyrene. PCB match data were excellent for collocated samples on both days of sampling. Considering the extremely high concentrations of PCBs detected in surficial soil samples at Site G (see Section 4.2.3), the detection of PCBs in the downwind air samples constitutes an observed release for HRS scoring purposes.

Although problems were encountered in the semivolatile analysis of the cartridges (as discussed previously), careful review of the data indicated that the fluorene, 2-nitroaniline, benzyl alcohol, fluoran-

thene, and pyrene detected are acceptable for use in HRS scoring. All of these compounds were also frequently detected and at relatively high concentrations in surficial soil samples from Site G. In contrast, the semivolatile compounds detected in the background sample (DC-05) were not detected in any of the surface soil samples. This relationship, in conjunction with the sample locations at which the compounds were detected, provides adequate support that the listed airborne contaminants resulted from site conditions.

Because benzene was detected in blank samples, it can not be substantiated for use in HRS scoring. The semivolatile compounds detected in the background sample (DC-05) are probably the result of the previously discussed problems with the extraction procedure and column decomposition. The metals analyses did not indicate any substantial trends or significant differences in concentrations between upwind and downwind samples. For this reason, the data for metals are not considered to constitute a release of contaminants from the site.

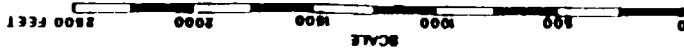
Meteorological data were obtained from the Bi-State Parks Airport in Cahokia for the sampling dates. Due to the industrial nature of the project area, wind speed and particularly wind direction are important factors to consider when discussing results for air sampling. Wind roses for the intervals sampled are included on Figures 4-49 and 4-50. Although the preferred wind direction for sampling at Site G/CS-B was from the southwest, the south and southeasterly winds which prevailed during the sampling were acceptable for monitoring site conditions. No potential sources, other than the sites being monitored, are located within a reasonable distance to the south or southeast of the sampling area. This provides further substantiation that the contaminants detected in air samples at Site G/CS-B resulted from conditions at the sites.

4.2.6.3 Area 2 - Sites Q and R

Results

Analytical results for air samples collected at Sites Q and R are presented in Figures 4-52 and 4-53, and in Table 4-27.

ON JULY 21, 1967
SAMPLES AT SITES Q AND R
ORGANIC COMPOUNDS IN AIR



SCALE

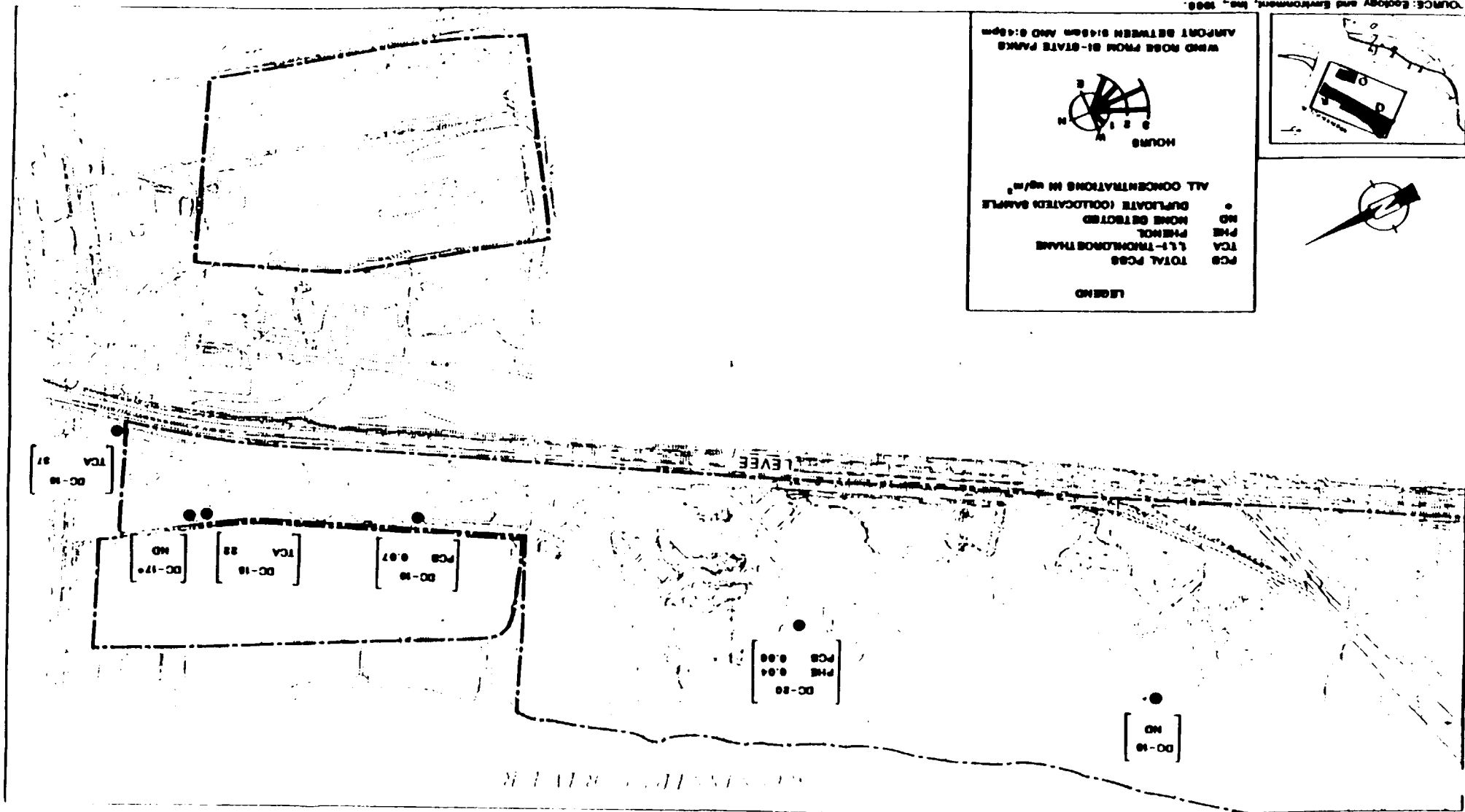
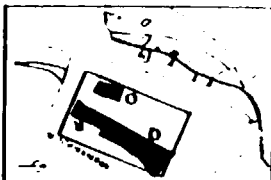
SOURCE: Ecology and Environment, Inc., 1968.

WIND ROSE FROM ST-STATE PARKS
AIRPORT BETWEEN 8:15am AND 8:45pm



• ALL CONCENTRATIONS IN $\mu\text{g}/\text{m}^3$
• DUPLICATE (COLLOCATED) SAMPLE
• NONE DETECTED
• PRESENT
• TCA
• TOTAL PCBs

LEGEND



ST-STATE PARKS

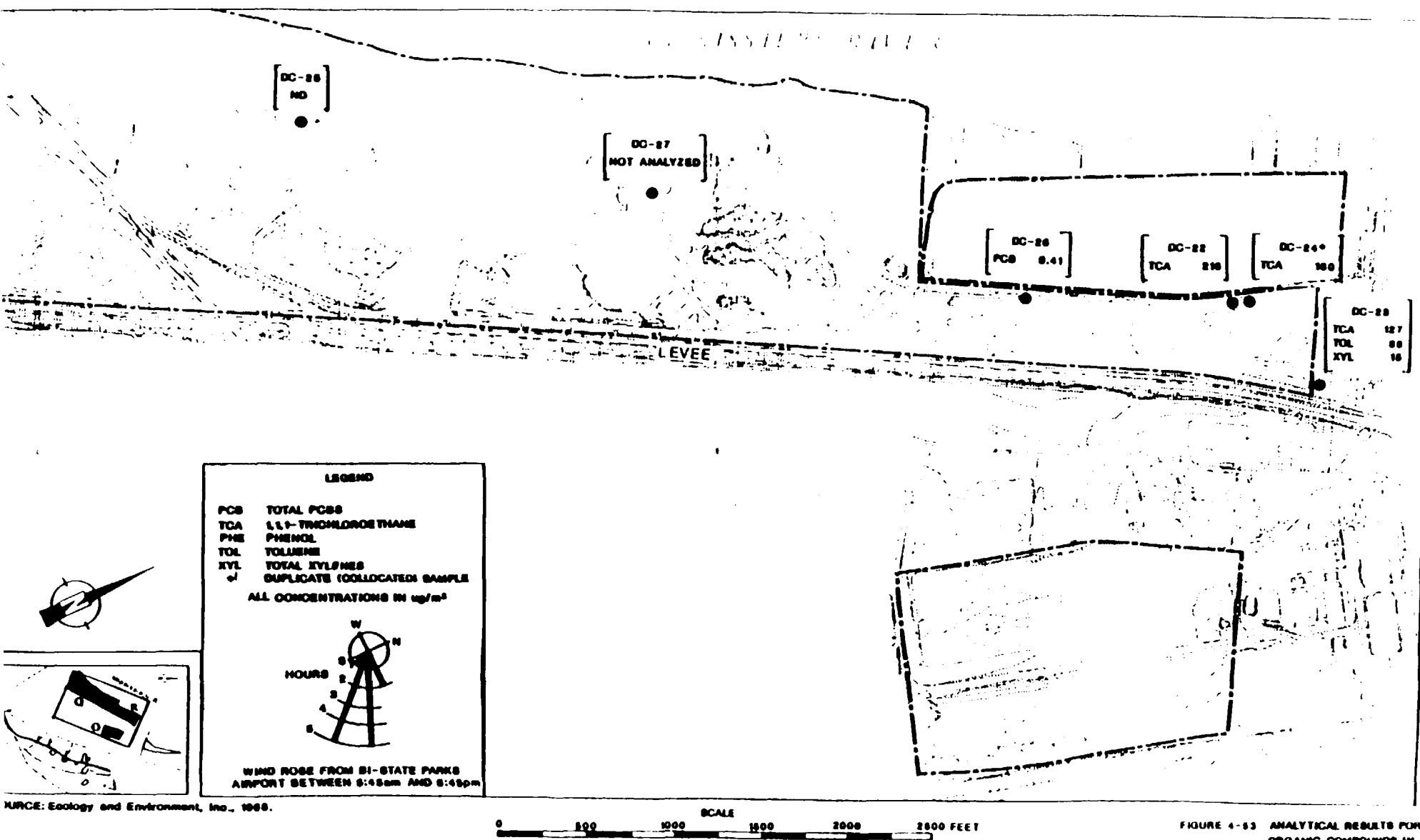


FIGURE 4-53 ANALYTICAL RESULTS FOR SELECT ORGANIC COMPOUNDS IN AIR SAMPLES AT SITES Q AND R ON JULY 22, 1987

Table 4-27

SUMMARY OF AIR SAMPLING RESULTS FOR SITES Q AND R

Compound	Sample Number													
	DC-15†	DC-16	DC-17†	DC-18	DC-19	DC-20	DC-21*	DC-22†	DC-23	DC-24†	DC-25	DC-26	DC-27	DC-28*
benzene	58JB	61JB	61JB	72JB	74JB	NA	17JB	71JB	92JB	84JB	79JB	76JB	NA	18JB
naphthalene	--	--	--	--	--	--	--	--	--	--	--	--	--	--
pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1,1-trichloroethane	22	37	--	--	--	--	--	216	127	160	--	--	NA	--
phenol	--	--	--	--	--	0.04J	--	--	--	--	--	--	--	--
toluene	--	--	--	--	--	--	--	--	88	--	--	--	NA	--
total xylenes	--	--	--	--	--	--	--	--	15	--	--	--	NA	--
Aroclor 1248	--	--	--	--	0.07	0.06	--	--	--	--	--	0.19	NA	--
Aroclor 1254	--	--	--	--	--	--	--	--	--	--	--	0.13	NA	--
Aroclor 1260	--	--	--	--	--	--	--	--	--	--	--	0.09	NA	--
chromium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
copper	0.86	0.58	0.81	0.63	0.88	0.31	--	1.14	1.22	0.82	0.61	0.56	NA	--
lead	0.19	0.25	0.27	0.34	0.30	0.29	--	0.45	0.79	0.54	0.39	0.30	NA	--
zinc	0.47	0.96	0.68	0.20	0.61	0.17	--	1.20	1.69	1.74	1.34	2.02	NA	--

All results in $\mu\text{g}/\text{m}^3$.

Samples DC-15 through DC-21 collected 7/21/87. Samples DC-22 through DC-28 collected 7/22/87.

† Duplicate (collocated) samples.

* Blank samples - results reported in μg per sample medium (filter, cartridge).

J Indicates estimated value. Result is less than the specified detection limit, but greater than zero.

B Compound also found in blank sample.

NA Not analysed.

-- Not detected.

Source: Ecology and Environment, Inc. 1988.

Volatile Organics. Volatile compounds detected included 1,1,1-trichloroethane, toluene, and total xylenes. The compound 1,1,1-trichloroethane was detected in two samples (DC-15 and DC-16) on the first day of sampling, and three samples (DC-22, DC-23, and DC-24) on the second day. Toluene and xylenes were detected only in DC-23, collected on the second day of sampling. Benzene was detected in all of the samples, but was also detected in the blank samples.

Semivolatile Organics. As discussed previously, the high-volume PUF cartridges from these samples were not analyzed for semivolatile compounds. Particulate filters and PUF sorbent tubes were analyzed for semivolatiles. Phenol was the only semivolatile compound detected. The phenol was detected only in sample DC-20, collected on the first day of sampling.

Pesticides and PCBs. PCBs were detected in two samples on the first day of sampling, and in one sample on the second day. Aroclor 1248 was detected in samples DC-19 and DC-20, with a high concentration of 0.07 ug/m^3 in DC-19. Three PCB congeners (Aroclors 1248, 1254, and 1260) were detected in sample DC-26, with a total concentration of 0.41 ug/m^3 . No pesticide compounds were found in any of the samples.

Inorganics. Metals were detected in all samples submitted for analysis. Metals detected included copper, lead, and zinc. Chromium was not detected in any of the samples. The highest concentration of copper was 1.22 ug/m^3 , in sample DC-23. The highest concentration of lead was 0.79 ug/m^3 , also in sample DC-23. The highest concentration of zinc was 2.02 ug/m^3 , in sample DC-26.

Discussion

Examination of the analytical results of air sampling conducted at Sites Q and R indicates a documentable release of phenol and PCBs. PCBs were detected on both days of sampling at the same sample location (samples DC-19 and DC-26). This sample location is in the area in which chemical wastes were uncovered during past excavation activities for a railroad spur. In addition, previous subsurface soil sampling around

this area (see Site Q in Appendix A) had indicated high concentrations of PCBs in site soils. Considering the high permeability of surface material (cinders) at the site, a release of subsurface contaminants to the atmosphere is not unexpected. Similarly, previous analytical data from samples collected in the vicinity of sample DC-20 indicated the presence of phenol (PCBs were not analyzed for in these samples).

The volatile contaminants detected in samples DC-15, DC-16, DC-22, DC-23, and DC-24 must be closely scrutinized because other potential sources are located in the vicinity of these samples. Trade Waste Incineration, Inc. (TWI) is located immediately east of the northeast corner of Site Q. Clayton Chemical Co. is located immediately to the southeast of TWI. Both facilities handle a wide variety of organic chemicals and wastes, although neither facility processes PCB wastes. The facilities are also separated from Site Q by a flood control levee.

The presence of these two facilities necessitates careful examination of site histories and meteorological conditions in order to determine the source of the volatile contaminants detected. Wind direction on the initial day of sampling was highly variable, but was predominantly from the south or southwest. In contrast, wind direction on the second day of sampling was predominantly from the southeast, which, in the absence of historical sample data, would indicate that the aforementioned facilities would be potential sources of the volatile contaminants detected. However, previous subsurface soil samples from Site Q had shown high concentrations of toluene (2,400 ppm) and xylenes (2,300 ppm). These previous sample data are synopsized in the Current Situation Report in Appendix A. Volatile compounds were detected only in the three northernmost sample locations (see Figures 4-52 and 4-53). Sample locations to the south of Clayton and TWI were unlikely to be influenced by these facilities, and contained no detected volatiles. As a result, more specific sampling is required to accurately determine the source for the volatile contaminants detected. In contrast, based upon previous sampling data and site conditions, the PCBs and phenol detected in air samples are attributable to Site Q. Site R could potentially be a supplemental contributor.

5. GROUNDWATER TRANSPORT MODELING

5.1 INTRODUCTION

As part of the DCP investigation, the groundwater flow regime and contaminant transport beneath the study area were modeled using computer simulations. These simulations were used to predict future movement of groundwater contaminants and estimate contaminant loading to the Mississippi River in the shallow and intermediate zones of the unconsolidated aquifer. The chosen study area for this task encompasses Sites G, H, I, L, O, Q, and R (see Figure 5-1). This area is 10,000 feet long and 8,500 feet wide. The western edge of the study area borders the Mississippi River.

A modified version of Plasm (Prickett and Lonquist 1971), developed by ISVS, was chosen as the groundwater model for this study. A modified version of the random walk solute transport model by Prickett et al. (1981) was chosen as the contaminant transport model.

5.2 GROUNDWATER MODELING

5.2.1 Groundwater Flow Model

Plasm is a finite difference model which can be used to predict one- or two-dimensional flow under artesian or groundwater flow conditions. The model can be used for simulating groundwater flow under heterogeneous, anisotropic, variable pumpage rate, lake/river/evapotranspiration, and steady or transient conditions. Plasm was modified for this study to incorporate the effect of seasonal river stages. The groundwater coefficients (permeability, transmissivity, and storage) were estimated based on aquifer testing, site hydrogeological con-

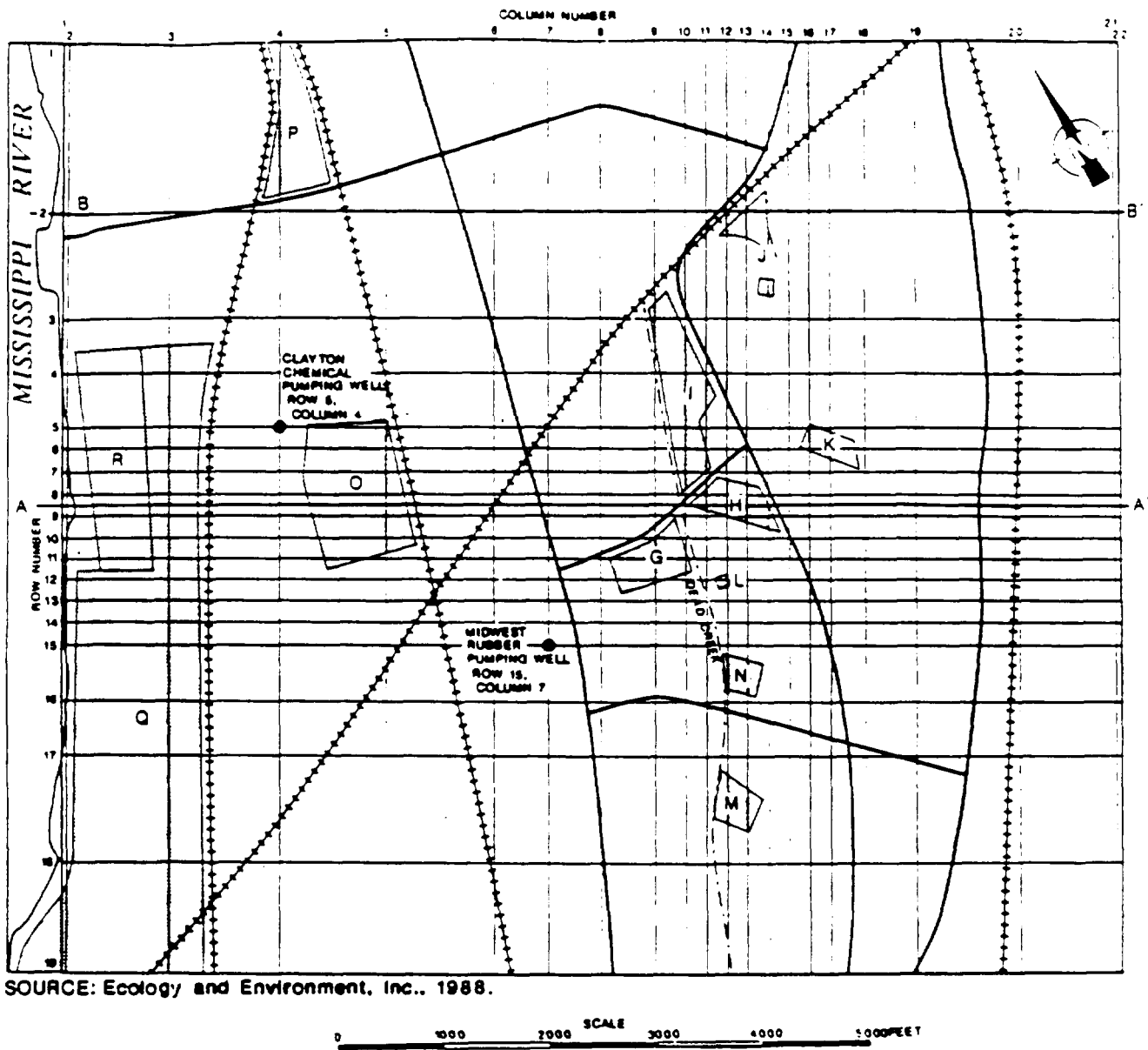


FIGURE 5-1 FINITE DIFFERENCE GRID PATTERN

ditions, and matching numerical head data with measured groundwater heads.

During this investigation, two-dimensional groundwater flow was simulated in the shallow and intermediate zones. By simulating two-dimensional flow in each zone and assuming a uniform vertical gradient between the two zones, a three-dimensional model was obtained.

5.2.2 Finite Difference Grid Patterns and Boundary Conditions

The grid pattern used in numerical simulation is presented in Figure 5-1. This variable grid pattern included 19 rows and 21 columns. A more condensed grid system was selected for the area including Sites G, H, and I, where more field measurement data were available for comparison with computer simulated data. Boundary conditions for the numerical simulation were based on the review of the available groundwater contours constructed from field data. The west boundary of the grid pattern borders the Mississippi River and groundwater heads at the nodes at this boundary coincide with the river heads. At the east boundary, a uniform groundwater flux in a direction normal to the river is prescribed corresponding to a groundwater gradient of 0.0011 feet/foot. At the north and south boundaries, zero groundwater fluxes are prescribed at directions parallel to the river. Since a symmetrical boundary condition was selected for the computer simulation, the groundwater flow pattern is generally toward the river (equi potential lines parallel to the river). For those computer simulations in which the effect of pumping from two wells was included, there was some shifting of the flow patterns. However, since the pumping volumes were low, the general flow pattern was basically unaffected by pumping.

5.2.3 Assumptions for Computer Simulations

A series of simplifying assumptions were made for the computer simulations.. The assumptions are as follows:

- The aquifer is homogeneous and isotropic.
- The bottom elevation of the shallow zone is 370 feet above MSL, and the bottom elevation of the intermediate zone is between 320

and 340 feet MSL. This assumption was based on data collected from soil borings performed by E & E, and a review of the literature (Bergstrom and Walker 1956; Geraghty & Miller 1986).

- The groundwater gradient in any vertical direction is uniform.
- The shallow zone is under water table conditions, and the intermediate zone is under confined conditions.
- The boundary conditions are as assumed in Section 5.2.2.
- The effect of precipitation and evapotranspiration is negligible, and river head fluctuation is the predominant factor affecting the groundwater heads in the study area. A comparison of groundwater heads in select monitoring wells and river stage data is presented in Table 5-1. The data show that groundwater heads fluctuate in response to river stage fluctuations, and that groundwater fluctuations are greater in areas closer to the river.
- Groundwater head elevations at the nodes bordering the Mississippi River vary each month, and groundwater heads at these nodes are equal to the average river head for each corresponding month. Table 5-2 shows average monthly Mississippi River heads from 1984 through 1987.

5.2.4 Groundwater Flow Coefficients

5.2.4.1 Permeability/Transmissivity

Permeability was calculated using E & E slug test data. Detailed descriptions of test locations and procedures are presented in Section 4.1.3.3. Based on the slug test results for Areas 1 and 2, permeability values for the shallow zone range from 1.5×10^{-5} to 5.2×10^{-4} ft/sec. The logarithmic average of permeability values was 7.5×10^{-5} ft/sec (48.70 gpd/ft²). The arithmetic average of permeability values was 12.7×10^{-5} ft/sec (82.5 gpd/ft²). (In averaging the permeability

Table 5-1

COMPARISON OF GROUNDWATER HEAD ELEVATIONS AND MISSISSIPPI RIVER STAGE ELEVATIONS
(IN FEET MSL)

Date*	River Head ⁽¹⁾	Groundwater Head ⁽²⁾	Groundwater Head ⁽³⁾	Groundwater Head ⁽⁴⁾
1-28-86	384.44	399.25	394.37	392.71
2-06-86	398.44	400.95	394.57	392.71
2-18-86	398.94	400.85	395.17	ND
4-08-86	402.94	399.65	396.37	396.71
4-30-86	397.94	400.05	396.97	396.41
5-23-86	410.44	399.45	397.17	397.91
6-25-86	394.44	399.55	397.97	397.31
7-17-86	407.94	399.15	ND	397.71
Maximum Fluctuation	26 ft	1.8 ft	3.6 ft	5.2 ft

* Dates listed represent river stage highs or lows.

(1) River stage data from Market Street gauge in St. Louis.

(2) GM1 located 7200 feet east of river.

(3) GM2 located 4200 feet east of river.

(4) GM3 located 3000 feet east of river.

Source: Adapted from Geraghty & Miller (1986).

Table 5-2

AVERAGE MONTHLY MISSISSIPPI RIVER HEADS FROM 1984 THROUGH 1987
(IN FEET MSL)

Year	Jan	Feb	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1984	387.19	397.94	401.94	407.94	408.94	407.44	404.44	387.44	385.44	388.94	395.94	389.90
1985	392.94	391.94	407.94	401.94	396.94	396.44	388.44	388.44	387.84	397.44	400.94	398.40
1986	388.44	392.44	395.94	400.94	403.44	399.44	399.44	392.44	ND	ND	ND	ND
1987	387.86	389.28	394.76	399.69	399.92	391.22	389.04	388.46	388.24	383.09	ND	ND
Ave. 1984-1987	389.11	391.66	400.15	403.00	402.31	398.64	395.34	389.20	387.21	389.82	398.44	394.10

ND No data available.

Source: 1984 through 1986 data, Geraghty & Miller, Inc. (1986).

1987 data, U.S. Army Corps of Engineers.

values, data from the following monitoring wells were used: EE-G101 and EE-G102 from Site G; EE-03, EE-04, and EE-G110 from Site H; EE-13, EE-15, and EE-G112 from Site I; EE-21, EE-24, and EE-25 from Site O; and EE-06 and EE-07 from Site Q).

Schicht (1965) reported permeability values for intermediate depths at six sites in Madison and St. Clair counties, Illinois. Based on these data, the mean permeability was $1,620 \text{ gpd/ft}^2$ ($2.5 \times 10^{-3} \text{ ft/sec}$) (Geraghty & Miller 1986a). An aquifer test conducted by Geraghty & Miller (1986a) in the intermediate zone provided a permeability value of $3,300 \text{ gpd/ft}^2$.

The transmissivity value for the shallow zone was calculated by multiplying the permeability value by the thickness of the saturated zone in this zone. The thickness of the saturated zone changes with fluctuations of the groundwater head, and therefore it varies as a function of time and distance from the river. The transmissivity value for the intermediate zone was calculated by multiplying the permeability value by the thickness of the intermediate zone. Thicknesses of 30 feet and 50 feet were used for the intermediate zone in this study.

5.2.4.2 Storage Coefficient

Values of storage coefficients calculated from slug tests performed in the shallow zone ranged from $0.1 \text{ ft}^3/\text{ft}^3$ to $0.00001 \text{ ft}^3/\text{ft}^3$. These values were calculated based on the assumption of a confined condition for the shallow zone. Schicht (1965) reported storage coefficients for the intermediate zone ranging from 0.020 to $0.155 \text{ ft}^3/\text{ft}^3$. Aquifer tests conducted by Geraghty & Miller (1986a) in the intermediate zone reported storage coefficient of $0.04 \text{ ft}^3/\text{ft}^3$.

5.2.5 Calibration of the Groundwater Flow Model

The groundwater flow model was calibrated to provide a basis for the selection of the best values for aquifer parameters. This calibration also provided a method for gauging the accuracy of the computer simulation data.

The model was calibrated by simulating groundwater heads from April 1, 1987, through September 30, 1987, and comparing the simulated data with the measured field data. Computer simulations were made using

average monthly Mississippi River heads. Average monthly river heads were calculated using daily river stage data provided by COE (see Table 5-2). Initial conditions were set equal to the field data measured on March 26, 1987. Because a time step of 15 days was selected for the computer simulation, simulated data for May 15, 1987, and September 30, 1987, were compared with the field data for May 12, 1987, and October 1, 1987, respectively (see Figures 5-2 and 5-3). Differences were noted, and reasons for these variations were determined. Parameters known to have an impact on water levels were adjusted, within the range of estimates for these parameters, to improve the match of simulated and field data. This process was repeated until the match was within a 1-foot head difference. This head difference is reasonable, considering the approximation in the computer simulation.

Groundwater model calibration was performed for both the shallow and intermediate zones. The following trials were performed for the shallow zone:

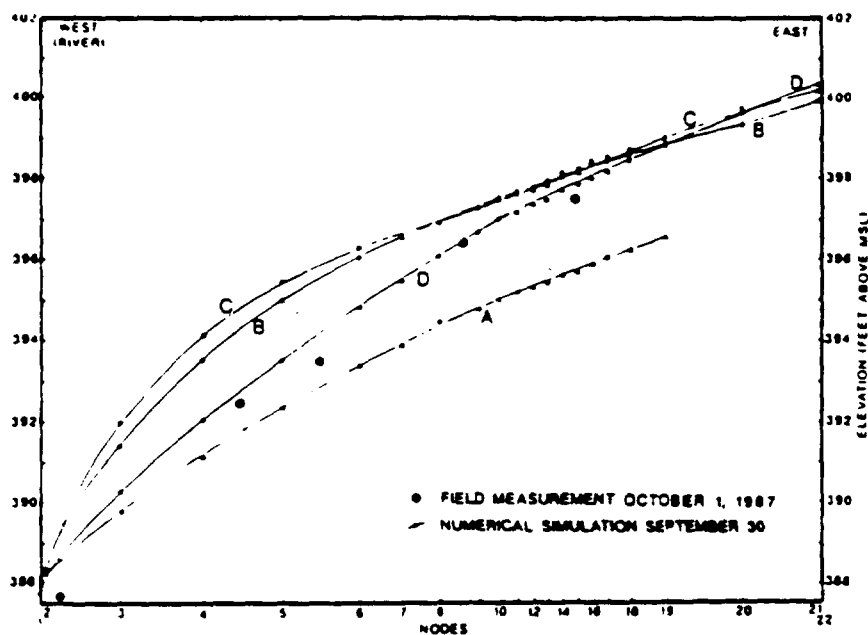
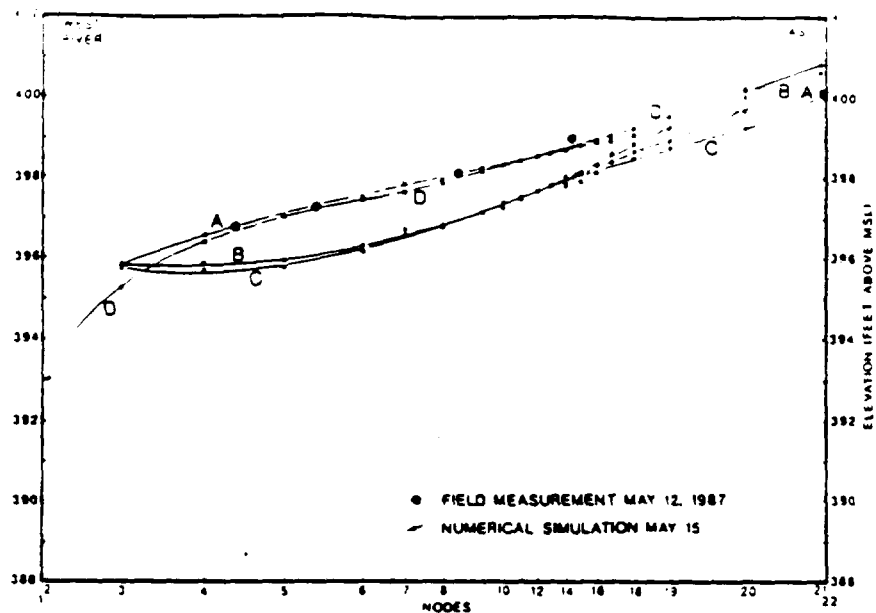
Trial	Hydraulic Conductivity (K) (gpd/ft ²)	Storage Coefficient(S) ft ³ /ft ³
A	82.5	0.001
B	82.5	0.01
C	48.7	0.01
D	48.7	0.001

The following trials were performed for the intermediate zone:

Trial	Hydraulic Conductivity (K) (gpd/ft ²)	Storage Coefficient(S) ft ³ /ft ³
A	3,300	0.11
B	2,000	0.11*
C	3,300	0.04
D	3,300	0.001
E	2,000	0.11**

* Assuming zone thickness is 50 feet and no pumps are running.

** Assuming zone thickness is 30 feet and two pumps are running.

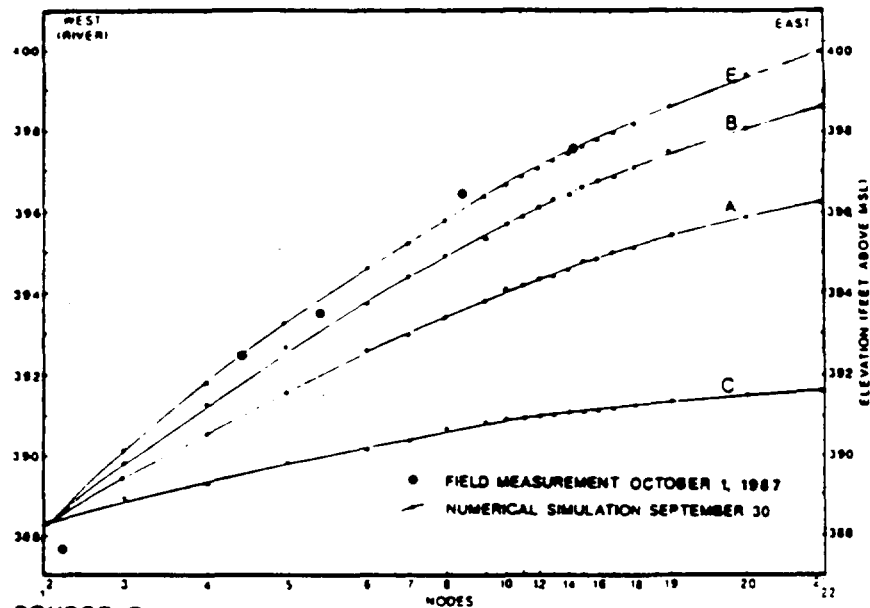
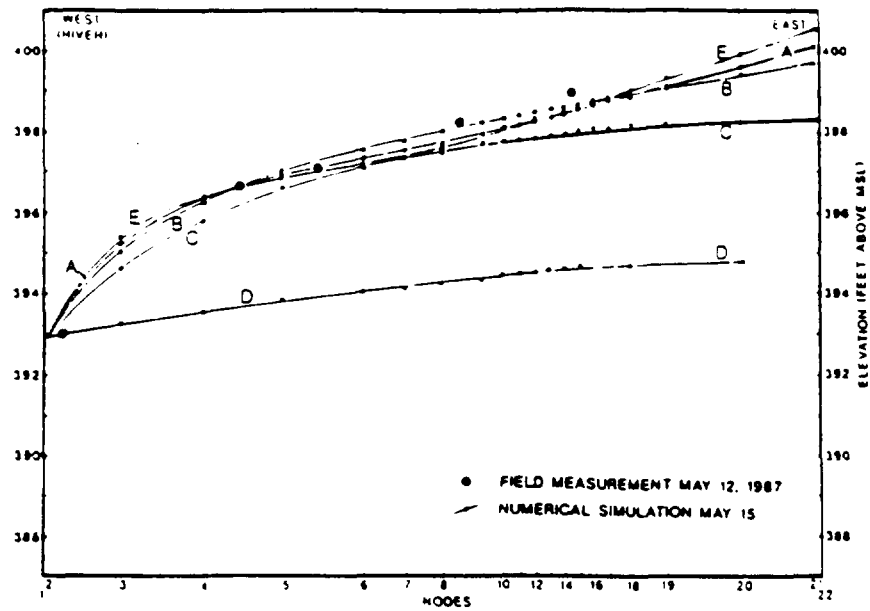


SOURCE: Ecology and Environment, Inc., 1988.

LEGEND

- | | |
|--|---|
| A NUMERICAL SIMULATION
$K=0.25 \text{ gpd/ft}^2$
$S=0.001 \text{ ft/ft}$ | C NUMERICAL SIMULATION
$K=0.7 \text{ gpd/ft}^2$
$S=0.01 \text{ ft/ft}$ |
| B NUMERICAL SIMULATION
$K=0.25 \text{ gpd/ft}^2$
$S=0.01 \text{ ft/ft}$ | D NUMERICAL SIMULATION
$K=0.7 \text{ gpd/ft}^2$
$S=0.001 \text{ ft/ft}$ |

FIGURE 5-2 CALIBRATION TESTS FOR SHALLOW ZONE, GROUNDWATER ELEVATIONS ALONG EAST-WEST DIRECTION



SOURCE: Ecology and Environment, Inc., 1988.

LEGEND

- | | |
|--|---|
| A NUMERICAL SIMULATION
K=3300 gpd/FT ²
S=0.11 FT/FT ²
T=16500 gpd/FT | C NUMERICAL SIMULATION
K=3300 gpd/FT ²
S=0.01 FT/FT ²
T=165000 gpd/FT |
| B NUMERICAL SIMULATION
K=3000 gpd/FT ²
S=0.11 FT/FT ²
T=100000 gpd/FT | D NUMERICAL SIMULATION
K=3300 gpd/FT ²
S=0.001 FT/FT ²
T=165,000 gpd/FT |
| E NUMERICAL SIMULATION
K=2,000 gpd/FT ²
S=0.11 FT/FT ²
T=50,000 gpd/FT
12 PUMPS RUNNING | |

FIGURE 5-3 CALIBRATION TESTS FOR INTERMEDIATE ZONE, GROUNDWATER ELEVATIONS ALONG EAST-WEST DIRECTION

In the shallow zone, trial D, with $K = 48.7 \text{ gpd/ft}^2$ and $S = 0.001$, best matched the field data. In the intermediate aquifer, trials B and E, with $K = 2,000 \text{ gal/sq ft per day}$ and $S = 0.11$, provided good matches with field data. These coefficients were then used in the numerical simulation of the average annual flow regime.

5.2.6 Average Annual Flow Regime

Subsequent to calibrating the groundwater flow model, computer simulations were performed to estimate/predict the average annual flow regime on a monthly time-step basis. Average monthly Mississippi River heads from 1984 through 1987 were calculated (see Table 5-2), and used for computer simulation. Groundwater heads and fluxes were calculated and represent the average heads and fluxes for the corresponding months.

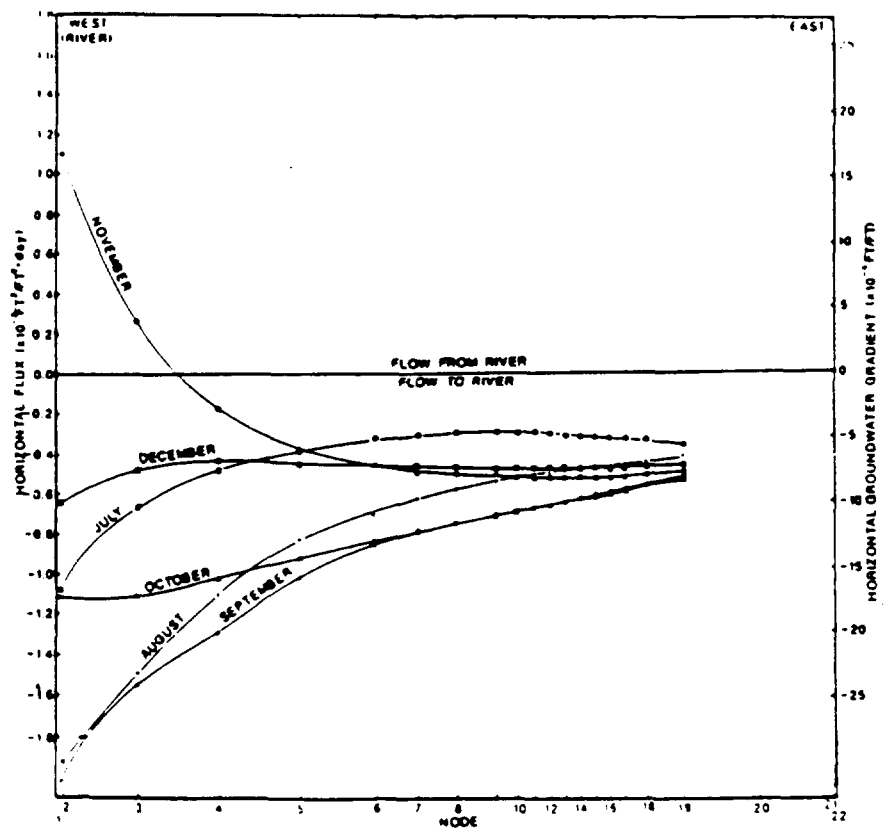
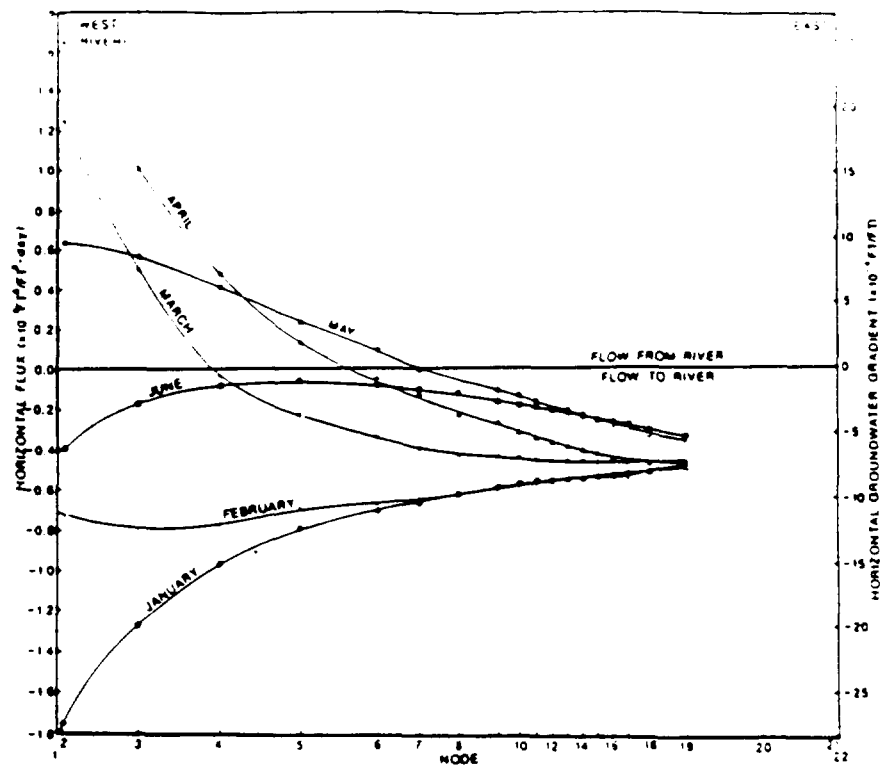
Computer simulations were made for both shallow and intermediate zones. For the intermediate zone, zone thicknesses of 30 feet and 50 feet were considered. The simulation using the 30-foot thickness was run, assuming that two pumps were each running at 1,000,000 gallons per month (see Figure 5-1 for pump locations). This assumption was made based on reports that pumping at these locations has averaged 1,000,000 gallons per month from each well (see Section 2.5).

Average annual flow data were later used to estimate residence time for contaminant transport from contaminant sources to the Mississippi River, and to estimate contaminant loading to the river.

5.2.6.1 Horizontal Groundwater Flux and Gradient

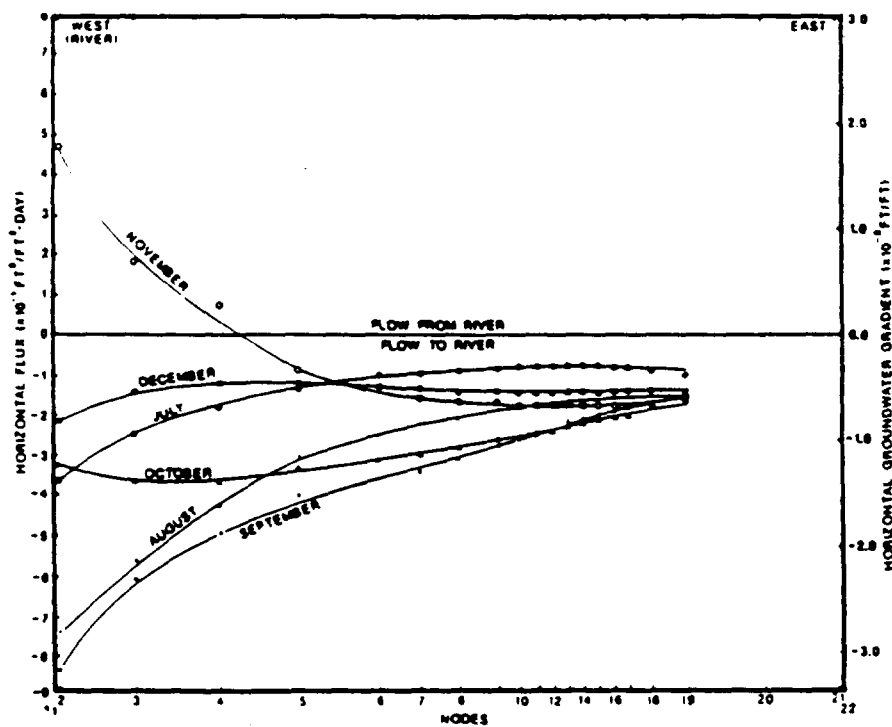
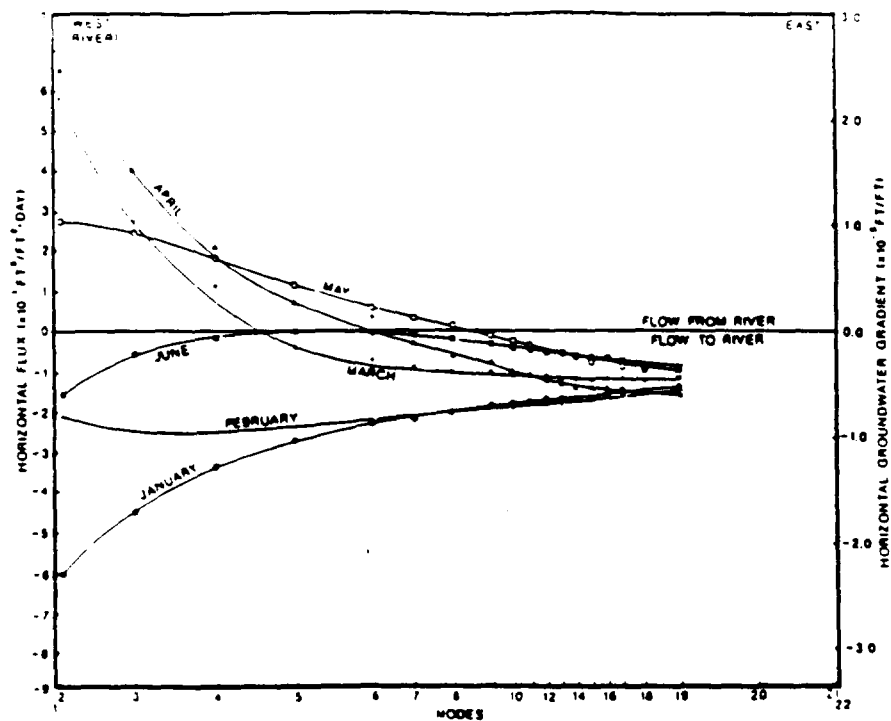
Average monthly groundwater fluxes and gradients corresponding to the average annual flow conditions were calculated using a post-processor to Plasm. These data for the shallow and intermediate zones are plotted in Figures 5-4, 5-5, and 5-6.

Based on these data, groundwater flow in March, April, May, and November is generally from the Mississippi River toward the sites (positive sign in the flow data). In the remaining months of the year, flow is generally toward the river (negative sign in the flow data). Based on these data, groundwater fluxes to the river in the shallow zone range from $0.0041 \text{ ft}^3/(\text{ft}^2 \text{ day})$ to $0.021 \text{ ft}^3/(\text{ft}^2 \text{ day})$ with the maximum value occurring at the river edge. These values correspond to



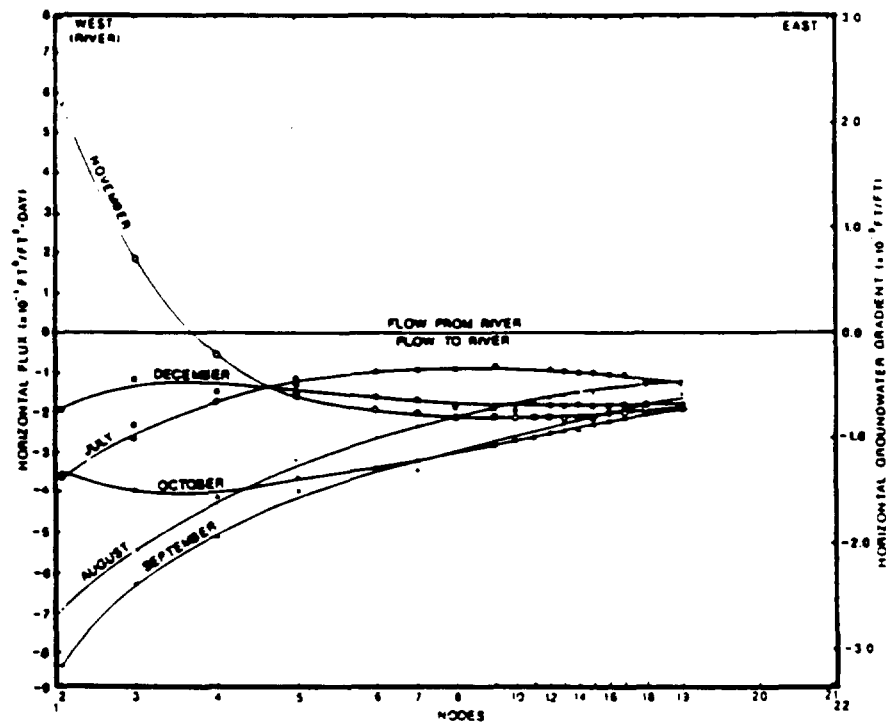
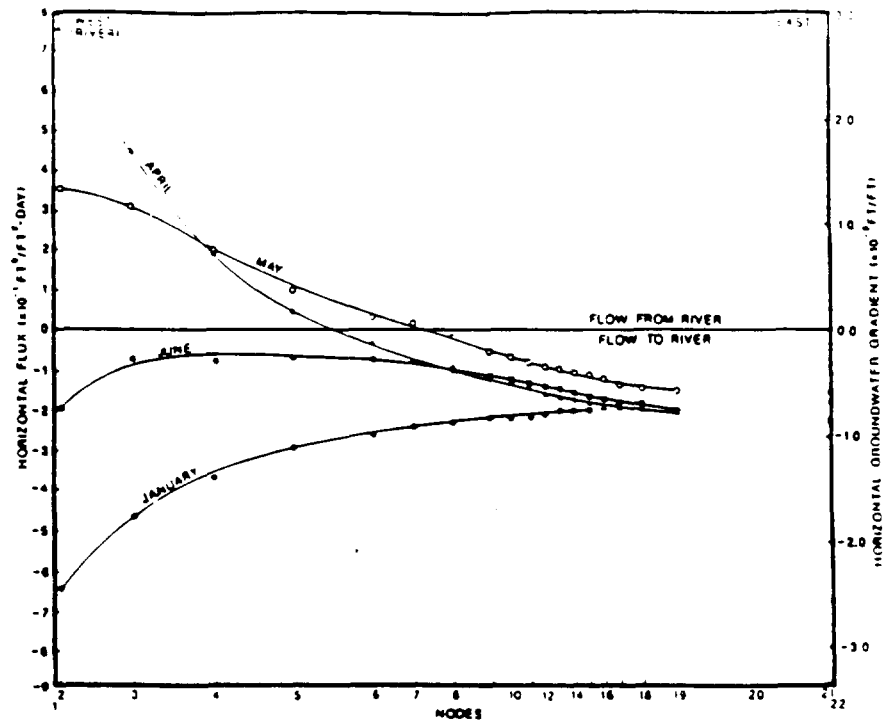
SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 5-4 ANNUAL FLUX/GRADIENT ALONG EAST-WEST DIRECTION IN THE SHALLOW ZONE



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 5-5 ANNUAL FLUX/GRADIENT ALONG EAST-WEST DIRECTION IN THE INTERMEDIATE ZONE (50' AQUIFER THICKNESS, NO PUMPING)



SOURCE: Ecology and Environment, Inc., 1988.
SEE FIGURE 5-1 FOR LOCATION OF A-A'

FIGURE 5-6 ANNUAL FLUX/GRADIENT ALONG A-A' IN THE INTERMEDIATE ZONE (30' AQUIFER THICKNESS, 2 WELLS PUMPING)

velocities of 0.027 ft/day to 0.14 ft/day (for effective porosity of $0.15 \text{ ft}^3/\text{ft}^3$). Groundwater fluxes to the river in the intermediate zone range from $0.15 \text{ ft}^3/(\text{ft}^2 \text{ day})$ to $0.81 \text{ ft}^3/(\text{ft}^2 \text{ day})$, with the maximum value occurring at the river edge. These values correspond to velocities of 1.0 ft/day to 5.4 ft/day.

Groundwater flux in the shallow zone is at a maximum during August and September, when the river head is at its lowest. Flux in the intermediate zone is also greatest during August.

In March, April, May, and November, when flow is from the river, a zero velocity line is formed in each zone. This line in the shallow zone extends a maximum of 4,520 feet east of the river (about 1,000 feet west of Site G) in May. The zero velocity line in the intermediate zone extends a maximum of 5,020 feet east of the river (about 500 feet west of Site G) in May. Table 5-3 shows average monthly flow data at the river boundary. These data indicate that the zero velocity lines in both shallow and intermediate zones do not extend to Site G.

5.2.6.2 Vertical Groundwater Gradient and Flux in the Shallow Zone

The Mississippi River generally constitutes a pressure release zone (sink) for the groundwater in the area. Groundwater pressure is transmitted faster in the intermediate zone than in the shallow zone. This results in a generally downward groundwater gradient in the shallow zone. In periods of high river stages, an upward gradient may exist in areas close to the river. Review of the field data reported by Geraghty & Miller (1986a) indicates that a downward gradient exists in the study area and at times these gradients are significantly greater than horizontal gradients.

Vertical groundwater gradients were calculated using groundwater heads from computer simulations of the shallow and intermediate zones. The vertical distances between heads were taken as the distances between midpoints of the shallow and intermediate zones. Plots of vertical gradient versus distance from the river are presented in Figures 5-7 and 5-8. Based on these data, groundwater flux in the shallow zone is generally downward (a positive gradient). The vertical gradient in-

Table 5-3

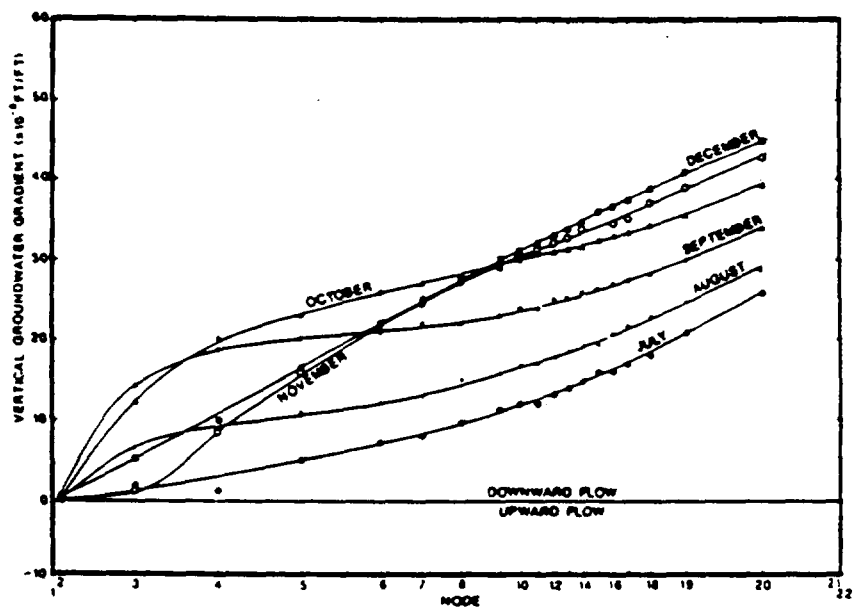
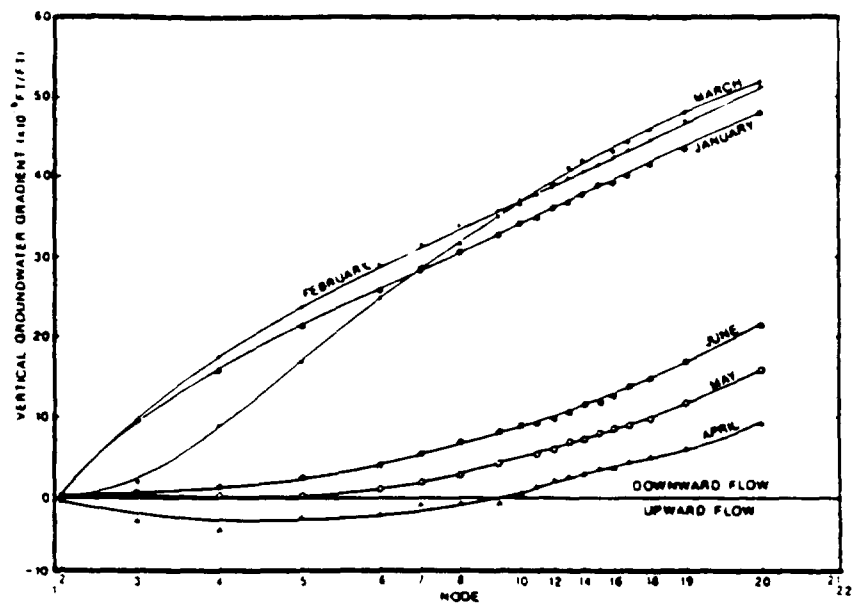
CALCULATED AVERAGE MONTHLY FLOW DATA AT THE RIVER BOUNDARY

Month	Shallow Zone				Intermediate Zone***			
	Flux (ft ³ /ft ² day)	Gradient* (ft/ft)	Velocity** (ft/day)	Divide line (ft east of river)	Flux (ft ³ /ft ² day)	Gradient* (ft/ft)	Velocity** (ft/day)	Divide line (ft east of river)
Jan.	-0.017	-0.0026	-0.113	--	-0.63	-0.0023	-4.2	--
Feb.	-0.0073	-0.00112	-0.049	--	-0.21	-0.00078	-1.4	--
March	+0.013	+0.002	+0.087	2,020	+0.57	+0.0021	+3.8	2,670
April	+0.018	+0.0027	+0.12	3,720	+0.65	+0.0024	+4.33	4,270
May	+0.006	+0.0009	+0.04	4,520	+0.27	+0.001	+1.8	5,020
June	-0.004	-0.0006	-0.027	--	-0.15	-0.00056	-1.0	--
July	-0.014	-0.002	-0.093	--	-0.37	-0.0014	-2.47	--
August	-0.0186	-0.0028	-0.124	--	-0.81	-0.003	-5.4	--
Sept.	-0.021	-0.003	-0.14	--	-0.76	-0.0028	-5.07	--
Oct.	-0.011	-0.0017	-0.013	--	-0.37	-0.0014	-2.47	--
Nov.	+0.011	+0.0017	+0.073	1,570	+0.47	+0.0017	+3.13	2,420
Dec.	-0.0064	-0.001	-0.043	--	-0.21	-0.0008	-1.4	--

* Horizontal gradient = flux/permeability (negative sign refers flow to the river).

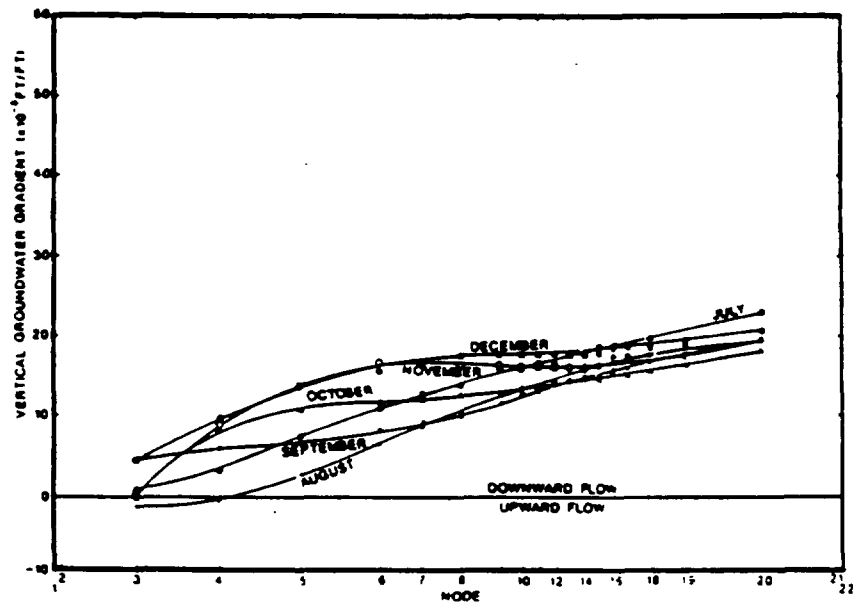
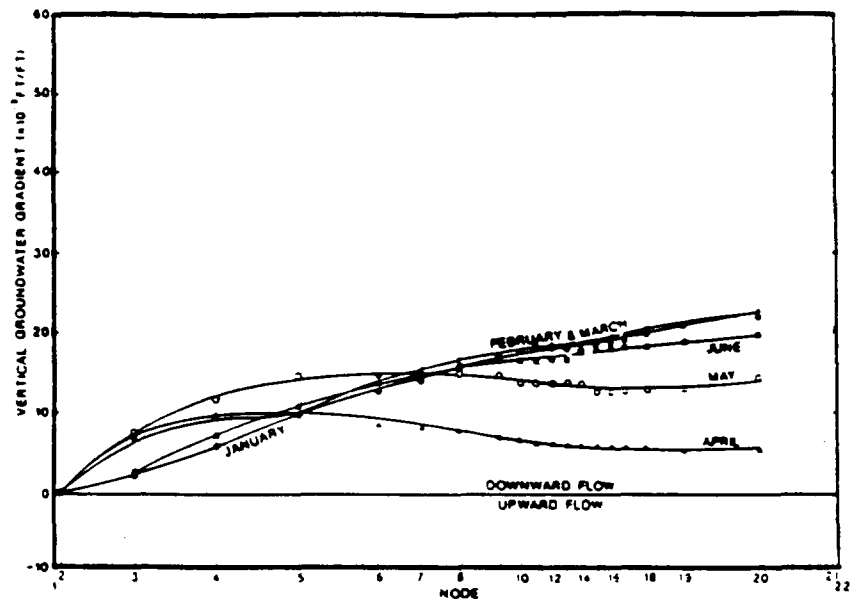
** Horizontal velocity = flux/effective porosity.

*** 50-foot-thick aquifer.



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 5-7 ANNUAL AVERAGE VERTICAL GRADIENT ALONG EAST-WEST DIRECTION
IN THE INTERMEDIATE ZONE (50' AQUIFER THICKNESS, NO PUMPING)



SOURCE: Ecology and Environment, Inc., 1988.

SEE FIGURE 5-1 FOR LOCATION OF B-B'

FIGURE 5-8 ANNUAL AVERAGE VERTICAL GRADIENT ALONG B-B' IN THE INTERMEDIATE ZONE (30' AQUIFER THICKNESS, 2 WELLS PUMPING)

creases with distance from the river. The ratio of vertical gradient to horizontal gradient also increases with distance from the river. This ratio is as high as 80 in the study area. An upward gradient (negative gradient) exists in areas close to the river during April and May, when the Mississippi River is at high stage (see Figure 5-7). This effect is not apparent in Figure 5-8 because of pumping in the intermediate zone. Based on these data, flow in the shallow zone, except in the vicinity of the river, is generally downward from the shallow zone to the intermediate zone. In the vicinity of the river (Site R), horizontal flow becomes significant, and horizontal gradient may become more significant than the vertical gradient.

Vertical groundwater flux was calculated by multiplying vertical permeability values by the vertical gradients. Vertical permeability was assumed to be equal to the horizontal permeability. These values were used to calculate contaminant migration from the shallow zone to the intermediate zone.

5.3 CONTAMINANT TRANSPORT MODELING

A random walk solute transport model (Prickett et al. 1981) was used to study contaminant transport in the DCP study area. This model is used to simulate contaminant transport in groundwater by incorporating the effects of convection, dispersion, and chemical reactions.

Prickett et al. (1981) has provided a detailed description of the mathematical representation of this model and the basis for its numerical solution. In summary, the mathematical representation of the contaminant concentration rate includes both dispersion and convection terms. The convection term, containing velocity, is solved by adaption of a finite difference scheme. The dispersion term is solved by adaption of the random walk technique, based on the similarity between contaminant distribution and normal distribution of a random variable. The computer code for this transport model reads aquifer data from the groundwater flow model, makes numerical calculations, and provides both graphical and numerical representations of the contaminant transport.

5.3.1 Contaminant Transport Coefficients

The transport coefficients required to run the random walk model include:

- Retardation factor (R_f),
- Longitudinal dispersivity (d_l), and
- Transverse dispersivity (d_t).

5.3.1.1 Retardation Factor

Retardation factor (R_f) is defined as the ratio of velocity of the groundwater to velocity of the contaminant. This ratio should be equal to or greater than one. The retardation coefficient is dependent on the organic carbon content (f_{oc}) of the porous media, and approaches 0 as the f_{oc} level becomes 0. Winter and Lee (1987) reported the following equation for R_f :

$$R_f = 1 + .63 f_m f_{oc} K_{ow}$$

where f_m is mass fraction of solid, and K_{ow} is the octanol-water partition coefficient. A retardation coefficient of 1.50 was used for the computer simulations in this study.

5.3.1.2 Longitudinal Dispersivity

Longitudinal dispersivity (d_l) is the characteristic property of the porous media. For granular material with porosity of less than 0.25, d_l generally ranges from 20 feet to 100 feet (Anderson 1979). The product of multiplication of the longitudinal dispersivity and groundwater flow velocity summed with the coefficient of molecular diffusion is the coefficient of hydrodynamic dispersion in the longitudinal direction (D_l). A longitudinal dispersivity of 50 feet was used for the study.

5.3.1.3 Transverse Dispersivity

Transverse dispersivity (d_t) is a factor affecting dispersion in a direction normal to the flow line. The product of multiplication of transverse dispersivity and groundwater flow velocity summed with the

coefficient of molecular diffusion is the coefficient of transverse hydrodynamic dispersion (D_t). The ratio of longitudinal dispersivity to transverse dispersivity ranges from 1 to 20 (Anderson 1979). A transverse dispersivity of 25 was used for this study.

5.3.2 Residence Time

Residence time is defined as the required time for a contaminant to reach the river from a site. Since groundwater flow in the shallow zone is predominantly in a vertical direction, contaminants which originate in the shallow zone will migrate downward and enter the intermediate zone. In the intermediate zone, the contaminant migration will be dominated by horizontal flow, and will flow westward to the river. The residence time will be the of the migration times in the shallow zone (downward) and in the intermediate zone (westward). Residence time is primarily dependent on the flow velocity (convection term); however it is also dependent on the dispersivity, and the rate of adsorption and desorption. Horizontal flow velocity in the study area is a function of time (monthly variation) and location (distance to river). Vertical flow velocity in the study area is assumed to be uniform along any vertical direction and varies only with time.

Contaminant migration velocity is calculated using the following equation.

$$V = \frac{Ki}{ne}$$

where V is groundwater velocity, K is permeability, i is the average annual gradient, and ne is the effective porosity.

In Sites G, H, I, and L, the average annual vertical gradient is 0.015 feet/foot. Using this gradient and an average annual flow path of 14.39 feet, downward migration time was calculated to be 22 days. (Flow path was considered to be equal to half the thickness of the saturated zone in the shallow zone). At Site O, the average annual vertical gradient and average annual flow path are 0.011 feet/foot and 13.46 feet, respectively. Using these data, the downward migration time was calculated to be 28 days.

Contaminants entering the intermediate zone will flow in a westward direction toward the river. Flow velocity in this zone is a function of time and distance to the river. Using the random walk model (Prickett et al. 1981), contaminants entering the intermediate zone near Site G will reach the Mississippi River in approximately 20 years (see Figure 5-9). Contaminants entering the intermediate zone in the area of Site O will reach the river in approximately 8 years (see Figure 5-10).

5.4 CONTAMINANT LOADING

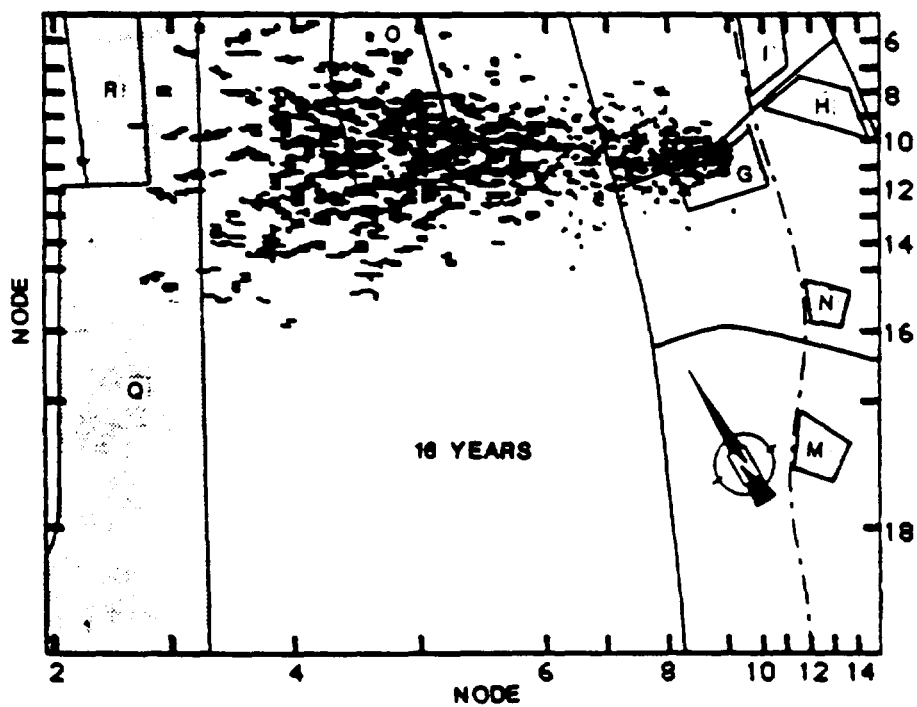
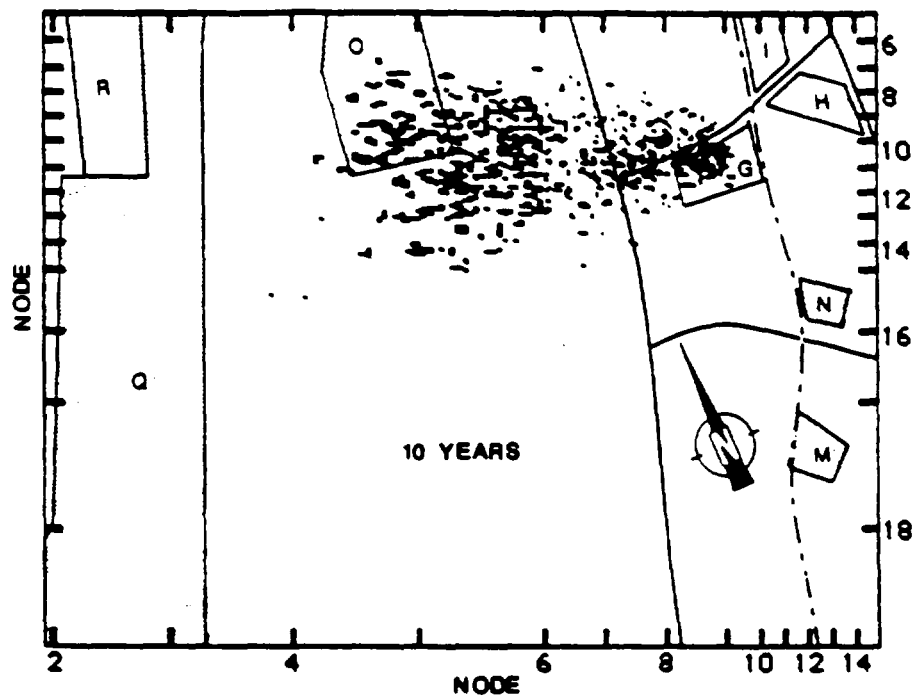
Contaminant loading to the river was estimated using average annual flow data found in the computer simulation. Table 5-4 presents the estimated annual average and maximum loading to the river from the shallow and intermediate zones. Summary tables showing contaminant loading to the river from each site are presented in the Appendix E. Based on these data, average and maximum values for total loading to the river from the shallow and intermediate zones are estimated to be 47.93 lb/day and 89.3 lb/day, respectively. If the contribution from the deep zone is included, the average and maximum values for loading to the river are estimated to be 69.93 lb/day, and 219.3 lb/day, respectively. The method of calculation of loading to the river is presented below. Two different methods based on site-specific conditions were used to estimate contaminant loading to the river from shallow and intermediate zones. These methods are described below.

5.4.1 Method 1

This method was used for Sites G, H, I, and L, where the approximate lateral and vertical extents of the waste zones (contamination sources) were defined in the DCP subsurface investigation. For these sites, loading was calculated based on the calculation of the flow components (Q_h , Q_v) leaving the waste zone. The horizontal flow rate (Q_h) and vertical flow rate (Q_v) for each site were calculated using the following relationships:

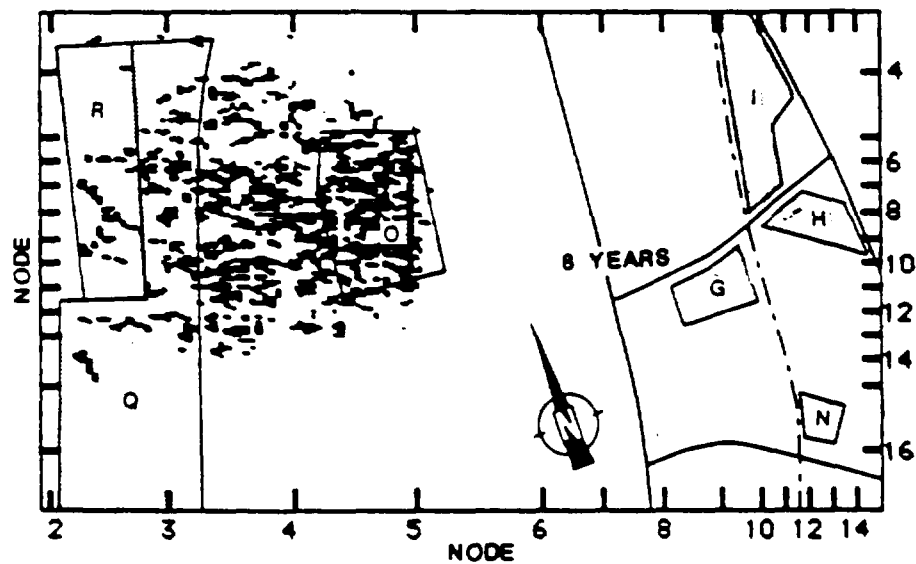
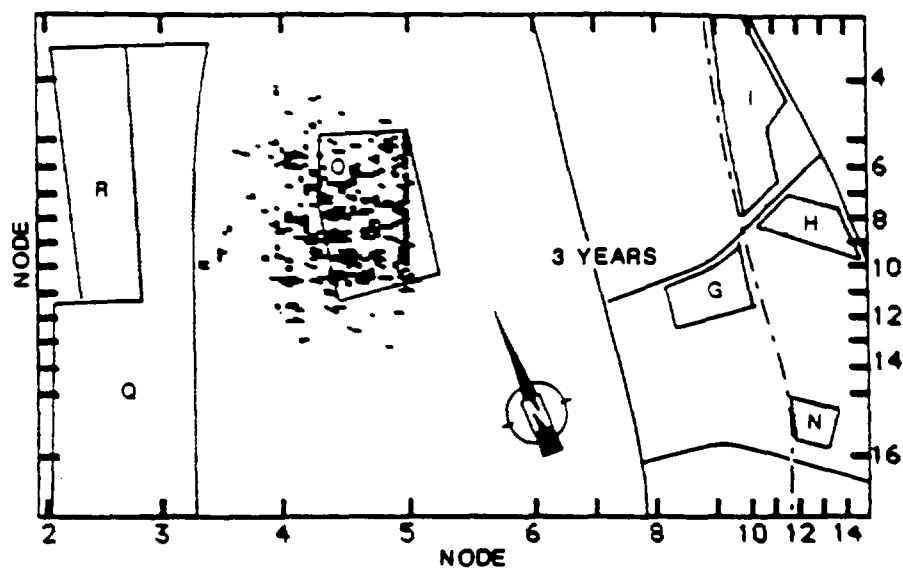
$$Q_h = K_h \times i_h \times A_v$$

$$Q_v = K_v \times i_v \times A_h$$



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 5-9 CONTAMINATION PLUME FROM SITE G



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 5-10 CONTAMINATION PLUME FROM SITE O

Table 5-6

ESTIMATED CONTAMINANT LOADINGS TO THE MISSISSIPPI RIVER

(IN LB/DAY)

Site	Total Organic Compounds		Select Volatiles		Select Carcinogenic PHAs		Select Non-Carcinogenic PHAs		Total PHAs		Total PCBs	
	Annual Average	Maximum	Annual Average	Maximum	Annual Average	Maximum	Annual Average	Maximum	Annual Average	Maximum	Annual Average	Maximum
G	16.71	20.49 December	1.42	1.74 December	2.24×10^{-3}	2.77×10^{-3} December	ND	ND	2.24×10^{-3}	2.77×10^{-3} December	3.95×10^{-2}	4.84×10^{-2} December
H	16.86	31.00 February	4.65	5.48 February	ND	ND	2.25×10^{-3}	2.71×10^{-3} February	2.25×10^{-3}	2.71×10^{-3} February	6.23×10^{-2}	7.46×10^{-2} February
I	5.85	6.91 February	1.23	1.45 February	ND	ND	1.45×10^{-3}	4.07×10^{-3} February	1.45×10^{-3}	4.07×10^{-3} February	ND	ND
L	4.24×10^{-1}	5.17×10^{-1} February	2.24×10^{-1}	2.76×10^{-1} February	ND	ND	ND	ND	ND	ND	ND	ND
O*	0.69	1.71 September	0.62	1.34 September	ND	ND	ND	ND	ND	ND	ND	ND
Q	5.54×10^{-3}	2.41×10^{-2} August	3.33×10^{-3}	1.32×10^{-2} August	ND	ND	ND	ND	ND	ND	ND	ND
R	0.19	48.57 September	4.00	23.02 September	ND	ND	ND	ND	ND	ND	ND	ND
Total	47.93	89.3	12.15	14.24	2.24×10^{-3}	2.77×10^{-3}	5.70×10^{-3}	6.78×10^{-3}	7.94×10^{-3}	9.55×10^{-3}	6.63×10^{-2}	1.23×10^{-1}

* Only 20% loading is reported for Site O; remainder is considered to be intercepted at Site R.

ND: Not Detected

Loadings listed here are for shallow and intermediate zones only.

Source: Ecology and Environment, Inc. 1988.

where K_v and K_h are equal and represent permeability; i_h and i_v are the horizontal and vertical groundwater gradients, respectively; and A_v and A_h are the estimated vertical and horizontal cross-sectional areas of the waste zones. Contaminant mass (m) leaving each site and eventually loading to the river was calculated using the following relationship:

$$m = Q \times C_{avg}$$

where Q is flow rate and C_{avg} is the average concentration of the contaminant detected in the water samples from monitoring wells in the corresponding site.

Since the waste zones in these sites terminate in the shallow zone, both Q_h and Q_v are flow rates in the the shallow zone. However, based on data from computer simulation, contaminants from shallow zone enter the intermediate zone in a relatively short time and flow horizontally toward the river. Due to the past pumping activities (see Section 4), it is very difficult to estimate the contaminant plumes. However, based on the present flow condition at the sites, as previously described, contaminants originating from Sites G, H, I, and/or L and moving in the intermediate zone will reach the river in approximately 20 years.

5.4.2 Method 2

Method 2 includes Sites O, Q, and R, where the lateral and vertical extents of the waste zones were not defined in the DCP subsurface investigations. In these sites, loading to the river (M) was calculated using contamination data from each individual well. Contamination data from each individual well were assumed to represent a flow zone halfway between that well and adjacent wells. In the shallow zone, only horizontal flow rate was considered, and the flow zone was considered to be between the water table and 370 feet MSL. In the intermediate zone, the flow zone was limited to elevations between 370 and 320 feet MSL. Loading to the river for both shallow and intermediate zones were calculated using the following equation:

$$M = \sum_{i=1}^n qA_iC_i$$

where n is the total number of monitoring wells used to calculate flow areas, q is the horizontal flux (Ki_h), and A_i and C_i are the cross-sectional flow area and contamination concentration corresponding to the monitoring well i , respectively. Since no E & E contamination data were available from the intermediate zone at Sites O and R, Geraghty & Miller (1986; 1986a) data were utilized to calculate contaminant loading to the river. Some portion of the contaminants originating from Site O is intercepted by the wells in Site R; therefore, based on the review of the contamination plume (see Figure 5-10), only 20% loading from Site O was considered in the total calculation of the loading to river. As described previously, contaminants originating from Site O will enter the river in approximately 8 years. Contaminants originating from Sites O and R will enter the river in less than 1 year.

Contaminant loading to the river from the deep aquifer was estimated based on the chemical data provided by Geraghty & Miller (1986). Based on these data, the loading to the river from the deep zone is 56.9 lb/day. However, considering the flow rate in the deep zone reported in the same report, it appears that the flow zone for this estimate also includes the intermediate zone. Therefore, the loading was recalculated to include only loading from the deep zone (320 feet MSL to bedrock). This recalculation resulted in an approximate average loading to the river of 22 lb/day. If the ratio between average and maximum loadings in the shallow and intermediate zones is utilized for the deep zone, the maximum loading from the deep zone may be estimated at approximately 130 lb/day.

5.5 SUMMARY AND CONCLUSIONS

Summaries and conclusions of this computer simulation may be outlined as follows:

- This simulation of groundwater flow and contaminant transport is conceptually reasonable and consistent with the hydrogeology of the study area.
- Average annual groundwater fluxes (monthly time step) and gradients were calculated and plotted for both shallow and inter-

mediate zones. Vertical hydraulic gradient in the shallow zone is significantly higher than horizontal gradient (except in the vicinity of the river), indicating predominantly vertical flow in the shallow zone. In the intermediate zone, flow is toward the river except in March, April, May, and November.

- Using the model, residence time was estimated for contaminants originating from each site. Based on these data, contaminants originating from the Sites G, H, I, and L reach the river in approximately 20 years. Contaminants originating from Site O reach the river in approximately 8 years.
- Loading to the river was estimated based on the assumption that any contaminants leaving the site eventually enter the river. The estimated average and maximum contaminant loadings are 69.93 lb/day and 219.3 lb/day, respectively.
- This computer simulation is bound to all of the limitations and errors common in all numerical simulations. Errors may arise from model limitations (two-dimensional model in a three-dimensional aquifer), incorrect aquifer data (transmissivities, storage coefficients), and numerical calculations (truncations and rounded-off errors).

The numerics defined for contaminant loading to the river are based on the information provided from groundwater flow and contaminant trans-simulation, and available groundwater quality data. Therefore they are bound to limitations and errors associated with numerical simulations and groundwater quality data. However, it is E & E's opinion that these are the best possible estimates based on the available data.

6. CONTAMINANT MIGRATION FATE AND IMPACT

6.1 INTRODUCTION

This section provides a qualitative assessment of the contaminants of concern, the migration and fate of contaminants, potential pathways of contaminant migration in terms of the possible receptors, and possible impacts of contaminants originating from the DCP area. This assessment will provide information for scoring the DCP sites using the HRS. In addition, this information provides some of the basic framework necessary for the future completion of an endangerment assessment for the DCP area.

Although contaminants may be detected at a hazardous waste site, this contamination does not necessarily imply that an adverse effect on human health, welfare, or the environment will occur. For an adverse effect to exist, each of the following conditions is required:

- o A source of contamination (e.g., spilled or dumped waste);
- o Release of the contaminant to a transport medium (e.g., leaching to groundwater);
- o Transport of the contaminant to a potential receptor location (e.g., groundwater movement to residential wells);
- o Exposure of the receptor to the contaminant (e.g., ingestion of the contaminant in drinking water); and

- o Exposure at a dose sufficient to produce an adverse effect (e.g., intake of enough chemical to cause physical damage).

The purpose of the following discussion is to present the elements of contaminant migration and fate, and to provide data which could be used to support a quantification of risk.

Although several migration/exposure pathways have been identified in this section, it should be emphasized that quantitative risks associated with these pathways have not been determined. The risks related to many of these identified pathways (e.g., dermal exposure to creek sediments) may be minimal, but the pathways are addressed in order to avoid the elimination of potential exposure routes. Further investigation is necessary to determine quantitative risks for the identified pathways, and to eliminate certain pathways from consideration.

6.2 CONTAMINANT SOURCE AND RELEASE

The following discussion describes the selection of contaminants of concern for this assessment and summarizes concentrations of these contaminants detected at DCP sites.

6.2.1 Selection of Contaminants of Concern

Section 4 of this report presented a detailed discussion of the concentrations of over 150 contaminants in groundwater, soil, and surface water and sediments. The data were screened according to EPA Superfund procedures to select indicator chemicals which would drive an endangerment assessment for human health and environmental receptors. Contaminants within each analyte group (volatile organics, semivolatile organics, pesticides and PCBs, and metals) were screened based on inherent toxicity and concentrations in the media. Screening by analyte group permitted selection of contaminants which possess physico-chemical properties indicative of mobility and/or persistence in the media of concern.

Carcinogenicity was the primary factor considered during the evaluation of contaminant toxicity. This emphasis was chosen because estimated carcinogenic unit cancer risks typically drive human health risk assessments. Contaminants were assessed based on EPA categorization as

group A carcinogens (human carcinogens) and group B carcinogens (potential human carcinogens). For noncarcinogens, heavy weighting was given to those with a high degree of chronic toxicity, that is those with low chronic reference doses (RfDs). Where available, estimated unit cancer risks and reference doses were extracted from the EPA Superfund Public Health Evaluation Manual (EPA 1986a).

The screening began with a listing of contaminants in the two source media, namely soil and groundwater. After this screening, data for Dead Creek sediments, surface water, and air were reviewed to determine whether additional contaminants should be added to the list. Table 6-1 summarizes the rationale for the selection of 25 contaminants of concern for the DCP sites and creek sectors.

Neither polychlorinated dibenzodioxins (PCDDs) nor polychlorinated dibenzofurans (PCDFs) were included as contaminants of concern, because, with the exception of limited 2,3,7,8-TCDD analyses conducted on sediments and surface soils, neither PCDDs nor PCDFs were subjected to specific analysis during this project. As a result, PCDDs and PCDFs were only occasionally identified in samples as tentatively identified compounds (TICs) and may have frequently been undetected due to elevated detection limits used during many analyses. Without an adequate analytical database for site characterizations, PCDDs and PCDFs could not be effectively incorporated into this assessment.

However, PCDDs and PCDFs may be present at the DCP sites in greater frequency and concentrations than the data currently support. Previous investigations at Site Q, Site R, and Creek Sector B identified the presence of 2,3,7,8-TCDD in soil and sediment samples, and this investigation identified high concentrations of PCBs and chlorophenols at the DCP sites (PCDDs and PCDFs frequently accompany these chemicals). Accordingly, PCDDs and PCDFs may require inclusion as contaminants of concern in any additional site investigations or detailed endangerment assessments.

6.2.2 Review of Contaminant Source and Release

Based on data developed during the project, each medium (soils, groundwater, surface water, sediments, and air) was examined for the presence of contaminants of concern. This subsection presents maximum

Table 6-1

CRITERIA FOR THE SELECTION OF CONTAMINANTS OF CONCERN FOR THE DCP SITES

Chemical Name	Medium Detected In					Carcinogenicity (oral)	Reference Dose
	Groundwater	Soil	Surface Water	Sediment	Air		
<u>Volatile Organics</u>							
benzene	x	x	x	x		x	N.A.
chlorobenzene	x	x	x	x			x
1,2-dichloroethane	x					x	N.A.
4-methyl-2-pentanone	x		x	x		x	N.A.
trans-1,2-dichloroethene	x						x
tetrachloroethene	x	x				x	N.A.
toluene	x	x					x
1,1,1-trichloroethane	x	x	x				x
trichloroethene	x	x	x			x	N.A.
<u>Semivolatile Organics</u>							
2-chlorophenol	x						x
2,4-dichlorophenol	x	x					x
pentachlorophenol	x	x					x
phenol	x	x		x			x
2,4,6-trichlorophenol	x	x				x	N.A.
dichlorobenzenes (3 isomers)	x	x		x			x
hexachlorobenzene		x				x	N.A.
naphthalene		x		x			

Table 6-1 (Cont.)

Chemical Name	<u>Medium Detected In</u>					Carcinogenicity (oral)	Reference Dose
	Groundwater	Soil	Surface Water	Sediment	Air		
polycyclic aromatic hydrocarbons	x	x	x	x	x	x (some)	N.A.
PCBs	x	x	x	x	x	x	N.A.
<u>Metals</u>							
arsenic	x	x	x	x			x
cadmium	x	x	x	x			x
lead	x	x	x	x			x
nickel	x	x	x	x			x

x Applicable.

N.A. Not applicable (carcinogen).

Source: Ecology and Environment, Inc. 1988.

concentrations by site area for the affected media. See Section 4 for a more complete discussion of contamination detected. Table 6-2 presents the maximum concentrations of contaminants of concern in individual surface soil samples at Sites G and J, the two sites where this medium was sampled. At Site G, high concentrations of pentachlorophenol, 1,4-dichlorobenzene, PCBs, PAHs, and heavy metals were reported; at Site J, heavy metals were the only contaminants indicated for this medium.

Table 6-3 presents the maximum concentrations of contaminants of concern in individual subsurface soil samples. In contrast to the surface soil results, substantial concentrations of volatile organics (e.g., benzene, chlorobenzene, etc.) were found in the subsurface soils. This contrast is consistent with these contaminants' ability to readily volatilize and/or migrate from surface soils to subsurface soils. Additionally, high concentrations of semivolatile organics (e.g., chlorophenol; 2,4-dichlorophenol; 2,4,6-trichlorophenol; pentachlorophenol; dichlorobenzenes; hexachlorobenzene; and PAHs), PCBs, and heavy metals were reported in subsurface soil samples at various DCP sites.

Table 6-4 summarizes the maximum concentrations of contaminants of concern in groundwater samples. For comparative purposes, this table also presents EPA drinking water maximum contaminant limits (MCLs) and maximum contaminant limit goals (MCLGs), health advisories (HAs), and reference concentrations for carcinogens corresponding to a 1×10^{-6} lifetime risk assuming the use of the groundwater as drinking water (EPA 1986a). As demonstrated in the table, groundwater associated with all DCP sites is contaminated and concentrations of many of the contaminants (e.g., benzene; 1,2-dichlorobenzene; tetrachloroethene; 2,4,6-trichlorophenol; pentachlorophenol; etc.) greatly exceed the MCLs, MCLGs, HAs, and/or reference concentrations for carcinogens at a number of sites.

Dead Creek surface water contained only low concentrations of a relatively few organic contaminants, and will not be subject to tabulation in this section. This is consistent with the fact that many of the contaminants volatilize from surface water, whereas the less water-soluble compounds partition to sediments.

Table 6-2

MAXIMUM CONCENTRATIONS OF SELECTED
CONTAMINANTS IN SURFICIAL SOIL (mg/kg)

Chemical Name	Site Designation	
	G	J
<u>Volatile Organics</u>		
benzene	0.1	--
chlorobenzene	0.04	--
1,2-dichloroethane	--	--
trans-1,2-dichloroethene	--	--
4-methyl-2-pentanone	--	--
tetrachloroethene	0.1	--
toluene	1.4	--
1,1,1-trichloroethane	--	--
trichloroethene	0.02	--
<u>Semivolatile Organics</u>		
phenol	0.1	--
2-chlorophenol	--	--
2,4-dichlorophenol	6.2	--
2,4,5-trichlorophenol	--	--
2,4,6-trichlorophenol	1.5	--
pentachlorophenol	21,000	--
naphthalene	120	--
1,2-dichlorobenzene	0.1	--
1,3-dichlorobenzene	--	--

Table 6-2 (Cont.)

Chemical Name	Site Designation	
	G	J
1,4-dichlorobenzene	22,000	--
hexachlorobenzene	10J	--
carcinogenic polycyclic aromatics	134	--
noncarcinogenic polycyclic aromatics	154.0	--
polycyclic aromatics (total)	200.0	--
PCBs (total)	74,000	--
<u>Total Organic Concentrations</u>	74,034.0	2.0
<u>Metals</u>		
arsenic	64R	9
cadmium	46	13R
lead	10,400	34
nickel	382	377

-- Not detected.

J - Estimated value - result is greater than zero, but less than the specified detection limit.

R - Spike recovery was outside control limits.

Source: Ecology and Environment, Inc. 1988.

Table 6-3

MAXIMUM CONCENTRATIONS OF SELECTED CONTAMINANTS
IN SUBSURFICIAL SOILS (mg/kg)

Chemical Name	<u>Site Designation</u>									
	G	H	I	J	K	L	N	P	O	Q*
<u>Volatile Organics</u>										
benzene	45.3	22.6	24.1	--	--	4.2	--	0.05	30.7	44
chlorobenzene	538.5E	451.6E	126.9	--	--	--	--	0.1	58.9	100
1,2-dichloroethane	0.4J	0.01	--	--	--	--	--	--	0.2	12
trans-1,2-dichloroethene	0.7J	--	0.003J	--	--	--	--	--	0.2	11
4-methyl-2-pentanone	6	7.9J	4.2	0.004J	0.01J	0.2	0.004J	0.05	7.7	250
tetrachloroethene	58.6	5.6	5.3	--	--	--	--	--	--	12
toluene	117.6	76.5	77.9	--	--	26.6	--	0.4	29.5	2,400
1,1,1-trichloroethane	--	--	1.7	--	--	--	--	--	1.4	--
trichloroethene	2J	.01J	3.8	--	--	--	--	--	0.07	55
<u>Semivolatile Organics</u>										
phenol	177.8	0.4J	27J	--	--	1.5J	--	3.9J	--	250
2-chlorophenol	8.8J	--	--	--	--	2.2	--	--	--	360
2,4-dichlorophenol	141.1J	741.9	--	--	--	--	--	--	--	3,100
2,4,6-trichlorophenol	49.5	612.9	--	--	--	--	--	--	--	170
pentachlorophenol	990.6	--	191.8	--	--	58.2	--	--	474.4J	100
1,2-dichlorobenzene	--	19,354E	139.7J	0.1J	--	--	--	3.6J	100	620
1,3-dichlorobenzene	--	241J	70.1	--	--	--	--	--	--	--

Table 6-3 (Cont.)

Chemical Name	Site Designation									
	G	H	I	J	K	L	N	P	O	Q*
1,4-dichlorobenzene	3.7J	30,645E	1,837	0.2J	--	0.2J	--	8.9J	112.8	1,200
hexachlorobenzene	40.6	0.7	1,270	--	--	--	--	--	--	--
naphthalene	5,428	2,265	514.5	17.9	0.2J	0.5J	--	--	34.6J	180
carcinogenic polycyclic aromatics	22.9	1,360	--	--	3.9	0.2	--	--	550	6
noncarcinogenic polycyclic aromatics	55.6	5,384	478.4	21.1	5.5	1.7	--	--	596.2	20
polycyclic aromatics (total)	68.6	6,744	478.4	21.1	9.4	1.6	--	--	1,146	26
<u>PCBs (total)</u>	4,428	885.5	270	0.2	117.6C	--	--	--	1,871	16,000
<u>Total Organic Concentration</u>	6,795	60,655	11,749	120.5	152	138.7	0.05	35.1	4,694	29,000
<u>Metals</u>										
arsenic	123R	388R	14	6	9	172	6	4	8	--
cadmium	14	294	13	4	4	6	--	4	31	--
lead	3,123	4,500	23,333	10	238	106	34	526	146	--
nickel	399	15,097	2,405	72	21	2,392	11	23	136	--

* Results from 1983 site investigation.

-- Not detected.

C Identification confirmed by GC/MS.

E Estimated value--amount detected in sample exceeds the calibrated range.

J Estimated value--result is greater than zero, but less than the specified detection limit.

R Spike recovery was outside control limits.

Source: Ecology and Environment, Inc. 1988.

Table 6-4

MAXIMUM CONCENTRATIONS OF SELECTED
CONTAMINANTS IN GROUNDWATER (in ug/L)

Drinking Water Standards or Criteria										
Chemical Name	MCL ^a	MCLG ^a	HA ^a	Reference Concentration for Carcinogens ^a	Site Designation					
					G	H	I	O	Q	R
Volatile Organics										
benzene	5	0	-	0.35	4,100	4,300	1,400	190,000	2,000	1,500
chlorobenzene	NS	NS	600	NA	3,100	11,000	3,100	150,000	6,700J	8,100
1,2-dichloroethane	5	0	--	0.95	480	--	120	4,000J	3,000	16,000
trans-1,2-dichloroethene	NS	70(p)	70	NA	200J	--	640	94J	4J	--
4-methyl-2-pentanone	NS	NS	NS	NA	2,200	3,600	230J	38,000	2,700	--
tetrachloroethane	NS	NS	NA	0.7	420	--	470	10,000	--	--
toluene	NS	2,000(p)	NS	NA	7,300	7,300	740	15,000	1,600J	760J
1,1,1-trichloroethane	200	200	NS	NA	--	--	--	7,800	--	--
trichloroethene	5	0	NA	2.0	800	--	270	83,000	2J	-
Semivolatile Organics										
phenol	NS	NS	NS	NA	30,000	950	1,800	500	190,000E	60,000E
2-chlorophenol	NS	NS	NS	NA	1,900	47J	370	120	33,000E	14,000E
2,4-dichlorophenol	NS	NS	105**	NA	480J	1,900	1,000	30J	14,000E	14,000E
2,4,5-trichlorophenol	NS	NS	3,500**	NA	--	580J	--	--	--	--
2,4,6-trichlorophenol	NS	NS	NA	1.7	350	1,200	290	--	6,000	2,100
pentachlorophenol	NS	200(p)	220	NA	6,300	650	2,400	23J	35,000E	--
1,2-dichlorobenzene	NS	620(p)	620	NA	200J	560	220J	7,800	2,000	340

Table 6-4 (Cont.)

<u>Drinking Water Standards or Criteria</u>										
Chemical Name	MCL*	MCLG*	HA*	Reference Concentration for Carcinogens*	Site Designation					
					G	H	I	O	Q	R
1,3-dichlorobenzene	NS	NS	NS	NA	4J	120	110	320	--	--
1,4-dichlorobenzene	75	75	75	NA	570	2,600	910	10,000E	250	550
hexachlorobenzene	NS	NS	NS	NA	6J	--	--	--	--	--
naphthalene	NS	NS	NS	NA	21,000E	250	230	160	70	82J
1,2,4-trichlorobenzene	NS	NS	4.2**	NA	1,900	720	2,700	270	390	--
carcinogenic polycyclic aromatics	NS	NS	NA	3×10^{-2} ***, †	38	--	--	--	--	--
noncarcinogenic polycyclic aromatics	NS	NS	NS	NA	--	15J	25J	--	--	--
total polycyclic aromatics	NS	NS	NS	NA	38	15J	25J	--	--	--
PCBs (total)	NS	O(p)	NS	8.1×10^{-3} ***	890	52	--	--	--	--
<u>Total Organic Concentrations</u>	NA	NA	NA	NA	256,850	44,573	27,977	588,657	326,420	129,531
<u>Metals</u>										
arsenic	50	50(p)	50	NA	175	8,490	20	133	100	46
cadmium	10	5(p)	5	NA	22R	70	--	8	--	--
lead	50	20(p)	20	NA	--	28R	--	--	--	--
nickel	NS	NS	150	NA	349	17,200	95	--	112	[18]

NS No standard or criterion.

NA Not applicable.

-- Not detected.

(p) Proposed.

Table 6-4 (Cont.)

- * Unless otherwise footnoted standards and criteria were extracted from EPA (1986).
- ** Calculated based upon reference dose (see text).
- *** Calculated based upon EPA estimated carcinogenicity potency factor (see text).
- † Based on benzo(a)pyrene EPA estimated carcinogenic potency.
- E Estimated value - amount detected in sample exceeds the calibrated range.
- J Estimated value - result is greater than zero, but less than the specified detection limit.
- R Spike recovery was outside control limits.
- [] Value is greater than or equal to the instrument detection limit, but less than contact required detection limit.

Source: Ecology and Environment, Inc. 1988.

Table 6-5 presents the maximum concentrations of contaminants of concern present in Dead Creek sediment samples. The Dead Creek sediments are primarily contaminated with PAHs, PCBs, and metals.

Air samples were collected at two DCP sites: Sites G and Q. The results of the air sampling identified PCB emissions from both sites. The limited amount of data obviates the need for tabulation of the air sampling results which were presented in Section 4.2.

6.3 ENVIRONMENTAL TRANSPORT AND FATE

6.3.1 Introduction

A variety of factors influence transport and fate. Subsection 6.3.2 addresses two significant factors, physico-chemical properties and the persistence of contaminants in environmental media, for the contaminants of concern at the DCP sites and creek sectors.

6.3.2 Physico-Chemical Properties and Persistence

Physico-chemical properties are important determinants of the transport and fate processes which directly affect the exposure potential for humans and environmental receptors. This subsection includes a generalized discussion of the properties of metals, followed by a discussion of the more important properties of organic chemicals. This is followed by a discussion of the potential contaminants of concern.

Metals in wastes may be in a metallic form, sorbed or chelated by organic matter or oxides, sorbed on exchange sites of waste constituents, or soil colloids, or in the soil solution. Most metals are immobile at usual soil pH ranges and become significantly leachable only if acidic solutions leach through the soils. At the normal range of soil pH values, metals have low concentrations in the soil solution and will not be leached at an appreciable rate. Other environmental factors which influence metal mobility include clay content, organic content, oxidation-reduction potential, carbonate content of soil, and groundwater or leachate chemistry.

Speciation of these chemicals is an important factor in their mobility. If the metals are present as oxides or hydroxides, they will remain relatively immobile. If they are present as soluble salts, the most likely reaction that may occur is the hydrolysis of metals to

Table 6-5

MAXIMUM CONCENTRATION OF SELECTED
CONTAMINANTS IN DEAD CREEK SEDIMENTS
(in mg/kg)

Chemical Name	Site Designation						Site M
	Creek Sector A	Creek Sector B	Creek Sector C	Creek Sector D	Creek Sector E*	Creek Sector F*	
<u>Volatile Organics</u>							
benzene	--	0.1J	--	--	--	--	--
chlorobenzene	0.5J	5.2	--	--	--	--	--
1,2-dichloroethane	--	--	--	--	--	--	--
trans-1,2-dichloroethene	--	--	--	--	--	--	--
4-methyl-2-pentanone	--	0.2J	--	--	--	--	--
tetrachloroethene	--	--	--	--	--	--	--
toluene	--	0.8	--	--	--	--	--
1,1,1-trichloroethane	--	--	--	--	--	--	--
trichloroethene	--	--	--	--	--	--	--
<u>Semivolatile Organics</u>							
phenol	--	--	0.6J	--	--	--	--
2-chlorophenol	--	--	--	--	--	--	--
2,4-dichlorophenol	--	--	--	--	--	--	--
2,4,5-trichlorophenol	--	--	--	--	--	--	--
pentachlorophenol	0.8J	0.9J	--	--	--	--	--
1,2-dichlorobenzene	0.5	17J	--	--	--	--	--
1,3-dichlorobenzene	0.6J	--	0.1J	--	--	--	--
1,4-dichlorobenzene	0.3	220	0.7J	--	--	--	--

Table 6-5 (Cont.)

Chemical Name	Site Designation						Site M
	Creek Sector A	Creek Sector B	Creek Sector C	Creek Sector D	Creek Sector E*	Creek Sector F*	
hexachlorobenzene	1.1J	1.9	--	--	--	--	--
naphthalene	0.1J	9.5J	0.3J	--	--	--	--
carcinogenic polycyclic aromatics	3.7	5.2	20	1.4	--	--	--
noncarcinogenic polycyclic aromatics	2.4	42.9	13.1	0.3	--	--	--
polycyclic aromatics (total)	5.3	48.1	41.1	1.4	--	--	--
PCBs (total)	95C	546C	23	12	2.0	--	20.0
<u>Total Organic Concentration</u>	143.6	883.5	108.9	127.6	--	--	59.3
<u>Metals</u>							
arsenic	76R	21R	33R	8R	--	--	16R
cadmium	31	36	42	42	31	2	11
lead	2,030	1,460	975	480	260	75	41
nickel	765	1,520R	1,290	665R	600	--	356R

* Results from 1980 IEPA investigation.

-- Not detected.

J Estimated value - result is greater than zero, but less than the specified detection limit.

R Spike recover was outside control limits.

Source: Ecology and Environment, Inc. 1988.

either oxides or hydroxides, or the precipitation of low-solubility sulfates or carbonates. When acids have also been spilled on the soils, the mobility of the metals will be increased until the acids have been neutralized by native soil alkalis. At present, it is difficult to evaluate the migration potential of metals in soils and groundwater at some DCP sites due to the complexity of chemical interactions, physical and chemical characteristics of soils, and biological processes in soils and groundwater.

As discussed in Section 6.2.1, 19 organic chemicals plus two chemical classes (PCBs and PAHs) were selected as potential contaminants of concern in soils, groundwater, surface water, sediments, and air at the DCP sites and creek sectors. The physico-chemical properties of the 19 organic chemicals are summarized in Table 6-6. PCB data are presented in Table 6-7. Data for 14 target compound list PAHs are shown in Table 6-8.

For the purpose of this section, vapor pressure, water solubility, Henry's Law (HL) constants, and soil-organic carbon partition coefficients (K_{oc} s) have been placed in four relative categories - very low, low, moderate, and high - corresponding to ranges of values separated by powers of ten. The relative categories for vapor pressure and water solubility were based on E & E judgment. Henry's Law constants were assigned a relative category compared to a value (4.6×10^{-3} atm-m³/mole) reported by McKay and Leinoner (1975) as representing the dividing line above which chemicals should be regarded as having high volatility from surface water. K_{oc} categories were referenced to a value of 100, below which chemicals can be regarded as highly or moderately mobile in terms of leachability from soils to groundwater and potential to partition from sediments to surface water. The categorization of the aforementioned parameters for selected contaminants of concern at the DCP sites and creek sectors is presented in Table 6-9.

Eight chemicals - benzene; chlorobenzene; 1,2-dichloroethane; trans-1,2-dichloroethene; tetrachloroethene; toluene; 1,1,1-trichloroethane; and trichloroethene - have relatively high environmental mobility characteristics. Each has a medium to high vapor pressure and low to moderate K_{oc} , indicating that volatilization will be an important pathway in surficial soils. The medium to high water solu-

Table 6-6

PHYSICO-CHEMICAL PROPERTIES FOR ORGANIC CONTAMINANTS OF CONCERN
FOR THE DEAD CREEK SITES*

Chemical Name	CAS No.	Molecular Weight (g/mole)	Water Solubility (mg/L)	Vapor Pressure (mm Hg at 25°C)	Henry's Law Constant (atm-m ³ /mole)	K _{oc} (mL/g)	log K _{ow}	BCF (L/kg)
benzene	71-43-2	78	1,750	95.2	5.6×10^{-3}	83	2.12	5.2
chlorobenzene	108-90-7	113	466	11.7	3.7×10^{-3}	330	2.84	10
2-chlorophenol		129	28,500 (20°C)	5 (28°C)***	$1.3 \times 10^{-5} \dagger \dagger \dagger$	200†††	2.17	
dichlorobenzenes	various	147	79-123	1.0-2.3	3.6×10^{-3}	1,700	3.6	56
1,2-dichloroethane	107-06-2 ¹	99	8,520	64	9.8×10^{-4}	14	1.48	1.2
trans-1,2-dichloroethane	540-59-0	97	6,300	208	7.6×10^{-3}	49	0.7	1.6
2,4-dichlorophenol	120-83-2	163	4,600	0.11	5.0×10^{-6}	380	2.75	4
tetrachlorobenzene	118-74-1	285	0.006	1.1×10^{-5}	6.8×10^{-4}	3,900	5.23	8,690
4-methyl-2-pentanone	108-10-1	100	6,500†	16 (20°C)**	$2.7 \times 10^{-5} \dagger$	45†	1.18**	
naphthalene	91-20-3	128	31.7	0.08	$1.1 \times 10^{-3} \dagger \dagger$	1,300	3.37	
PAHs (see Table 6-8)								
PCBs (see Table 6-7)								
pentachlorophenol	87-86-5	266	14	1.1×10^{-4}	2.8×10^{-6}	53,000	5	770
phenol	108-95-2	94	93,000	0.34	4.5×10^{-7}	14.2	1.46	1.4
tetrachloroethene	127-18-4	166	150	17.8	2.6×10^{-2}	364	2.6	31

Table 6-6 (Cont.)

Chemical Name	CAS No.	Molecular Weight (g/mole)	Water Solubility (mg/L)	Vapor Pressure (mm Hg at 25°C)	Henry's Law		Koc (mL/g)	log Kow	BCF (L/kg)
					Constant				
					(atm-m ³ /mole)				
toluene	108-88-3	92	535	28.1	6.4×10^{-3}		300	2.73	10.7
1,1,1-trichloroethene	71-55-6	133	1,500	123	1.4×10^{-2}		152	2.5	5.6
trichloroethene	79-01-6	131	1,100	57.9	9.1×10^{-3}		126	2.38	10.6
2,4,6-trichlorophenol	88-06-2	197	800	0.01	3.9×10^{-6}		2,000	3.87	150

ND No data.

* Unless otherwise footnoted, data extracted from EPA (1986a).

** Clement Associates, Inc. (1984).

*** Dawson et al. (1980).

† Estimated relative to methyl ethyl ketone.

†† Estimated based on Henry's Law constants for PAHs.

††† Estimated based on 2,4-dichlorophenol.

Table 6-7

PHYSICO-CHEMICAL PROPERTIES OF PCBs*

Aroclor Designation	Molecular Weight (ave. g/mole)	Color	Physical State	Water	Density (g/cm ³ at 25°C)	log K _{OW}	Vapor Pressure (mm Hg at 25°C)	Henry's Law**	BCF*** (L/kg)
				Solubility (mg/L)				Constant atm-m ³ /mol at 25°C	
1016	257.9	Clear	Oil	0.42	1.33	5.6	4 x 10 ⁻⁴	2.9 x 10 ⁻⁴	42,500
1221	200.7	Clear	Oil	0.59 (24°C)	1.15	4.7	6.7 x 10 ⁻³	3.5 x 10 ⁻³	
1232	232.2	Clear	Oil	Unknown	1.24	5.1	4.06 x 10 ⁻³	Unknown	
1242	266.5	Clear	Oil	0.24	1.35	5.6	4.06 x 10 ⁻⁴	5.2 x 10 ⁻⁴	
1248	299.5	Clear	Oil	0.054	1.41	6.2	4.94 x 10 ⁻⁴	2.8 x 10 ⁻³	70,500
1254	328.4	Lt. Yellow	Viscous liquid	0.012	1.50	6.5	7.71 x 10 ⁻⁵	2.8 x 10 ⁻³	100,000
1260	375.7	Lt. Yellow	Sticky resin	0.0027	1.58	6.8	4.05 x 10 ⁻⁵	4.6 x 10 ⁻³	190,000

* These log K_{OW} values represent an average value for the major components of the individual Aroclor.

** Henry's Law constants were estimated by dividing the vapor pressure by the water solubilities, and represent average values for the Aroclor mixtures as a whole (ATSDR 1987r).

*** From Lyman, Reehl, and Rosenblatt (1982).

Source: Unless otherwise specified, from ATSDR (1987l).

Table 6-8

PHYSICO-CHEMICAL PROPERTIES OF SELECTED PAHs*

Chemical Name	Molecular Weight (g/mole)	CAS No.	Vapor Pressure (mm Hg at 25°C)	Water Solubility (mg/L)	Henry's Law Constant (atm-m ³ /mole)	log K _{ow}	K _{oc} (mL/g)	BCF (L/kg)
acenaphthene	154	83-32-9	1.55×10^{-3}	3.42	9.2×10^{-5}	4.0	4.6×10^3	242**
anthracene	178	12-12-7	1.95×10^{-4}	4.5×10^{-2}	1.2×10^{-3}	4.45	1.4×10^4	1,210**
benzo(a)anthracene	228	56-55-3	2.2×10^{-8}	5.7×10^{-3}	1.16×10^{-6}	5.6	1.38×10^6	11,700**
benzo(b)fluoranthene	252	205-99-2	5.0×10^{-7}	1.4×10^{-2}	1.19×10^{-3}	6.06	5.5×10^5	--
benzo(k)fluoranthene	252	207-08-9	5.1×10^{-7}	4.3×10^{-3}	3.94×10^{-3}	6.06	5.5×10^5	--
benzo(g,h,i)perylene	276	191-24-2	1.03×10^{-10}	7.0×10^{-4}	5.34×10^{-8}	6.51	1.6×10^6	68,200**
benzo(a)pyrene	252	50-32-8	5.6×10^{-9}	1.2×10^{-3}	1.55×10^{-6}	6.06	5.5×10^6	28,200**
chrysene	228	208-01-9	6.3×10^{-9}	1.8×10^{-3}	1.05×10^{-6}	5.61	2.0×10^5	11,700**
dibenzo(a,h)anthracene	278	53-70-3	1.0×10^{-10}	5.0×10^{-4}	7.33×10^{-8}	6.8	33×10^6	--
fluoranthene	202	206-44-0	5.0×10^{-6}	2.6×10^{-1}	6.46×10^{-6}	4.9	3.8×10^4	2,920
fluorene	116	86-73-7	7.1×10^{-4}	1.69	6.42×10^{-5}	4.2	7.3×10^3	1,300***
indeno(1,2,3-cd)perylene	276	193-39-5	1.0×10^{-10}	5.3×10^{-4}	6.86×10^{-8}	6.5	1.6×10^6	--
phenanthrene	178	85-01-3	6.8×10^{-4}	1.0	1.59×10^{-4}	4.46	1.44×10^4	2,630**
pyrene	202	129-00-3	2.5×10^{-6}	1.32×10^{-1}	5.4×10^{-6}	4.88	3.8×10^4	2,800**

* Unless otherwise footnoted, data taken from EPA (1986a).

** EPA (1984i).

*** Lyman, Reehl, and Rosenblatt (1982).

Table 6-9

CHARACTERISTICS OF CONTAMINANTS OF CONCERN

Chemical Name	Vapor Pressure (mm Hg at 25°C)	Water Solubility (mg/L at 25°C)	Henry's Law Constant (atm-m ³ /mol)	K _{oc} (mL/g)
benzene	Moderate (10-99)	High (>100)	High (>5 x 10 ⁻³)	Low (10-100)
chlorobenzene	Moderate (10-99)	High (>100)	Moderate (5 x 10 ⁻⁴ to 5 x 10 ⁻³)	Moderate (100-1,000)
2-chlorophenol	Low (0.1-9.9)	High (>100)	Low (5 x 10 ⁻⁵ to 5 x 10 ⁻⁴)	Moderate (100-1,000)
dichlorobenzenes (isomers)	Low (0.1-9.9)	Moderate (10-100)	Moderate (5 x 10 ⁻⁴ to 5 x 10 ⁻³)	High (1,000 to 10,000)
1,2-dichloroethane	Moderate (10-99)	High (>100)	Moderate (5 x 10 ⁻⁴ to 5 x 10 ⁻³)	Low (10-100)
trans-1,2-dichloroethene	High (>100)	High (>100)	High (>5 x 10 ⁻³)	Low (10-100)
2,4-dichlorophenol	Very low (<0.1)	High (>100)	Very low (<5 x 10 ⁻⁵)	Moderate (100-1,000)
hexachlorobenzene	Very low (<0.1)	Very low (<0.1)	Moderate (5 x 10 ⁻⁴ to 5 x 10 ⁻³)	High (1,000-10,000)
4-methyl-2-pentanone	Moderate (10-99)	High (>100)	Very low (<5 x 10 ⁻⁵)	Low (10-100)
naphthalene	Very low (<0.1)	Moderate (10-100)	Low (5 x 10 ⁻⁵ to 5 x 10 ⁻⁴)	High (1,000-10,000)
PAHs	Very low (<0.1)	Very low (<0.1)	Very low (<5 x 10 ⁻⁵)	Extremely high (>10,000)
PCBs	Very low (<0.1)	Very low (<0.1)	Very low (<5 x 10 ⁻⁵)	Extremely high (>10,000)
pentachlorophenol	Very low (<0.1)	Moderate (10-100)	Very low (<5 x 10 ⁻⁵)	Extremely high (>10,000)
phenol	Low (0.1-9.9)	High (>100)	Very low (<5 x 10 ⁻⁵)	Low (10-100)
tetrachloroethene	Moderate (10-99)	High (>100)	High (>5 x 10 ⁻³)	Moderate (100-1,000)
toluene	Moderate (10-99)	High (>100)	High (>5 x 10 ⁻³)	Moderate (100-1,000)
1,1,1-trichloroethane	High (>100)	High (>100)	High (>5 x 10 ⁻³)	Moderate (100-1,000)

Table 6-9 (Cont.)

Chemical Name	Vapor Pressure (mm Hg at 25°C)	Water Solubility (mg/L at 25°C)	Henry's Law Constant (atm-m ³ /mol)	K _{oc} (mL/g)
trichloroethene	Moderate (10-99)	High (>100)	High (>5 x 10 ⁻³)	Moderate (100-1,000)
2,4,6-trichlorophenol	Very low (<0.1)	High (>100)	Very low (<5 x 10 ⁻⁵)	High (1,000-10,000)

Source: Ecology and Environment, Inc. 1988.

bilities and low to moderate K_{oc} s indicate that transport to groundwater is a major transport route. The physico-chemical properties suggest that transport of these chemicals to the water table will be only moderately retarded relative to the infiltration rate of rainwater. The same parameters, along with the high HL constants for these compounds, also indicate that volatilization from surface water will be an important transport pathway, whereas partitioning to sediments will be far less significant.

Seven other chemicals - 2,4-dichlorophenol; hexachlorobenzene; naphthalene; PAHs; PCBs; pentachlorophenol; and 2,4,6-trichlorophenol - have relatively low environmental mobility characteristics. Each has a low or extremely low vapor pressure, low to moderate water solubility, high K_{oc} , and low HL constant. The low vapor pressures and high K_{oc} s indicate that these chemicals will be strongly bound to surficial soils. These two factors, plus the low HL constants, also indicate that these seven chemicals will strongly partition to sediments subsequent to transport to surface water. Finally, as stated previously, the low to moderate water solubilities and high K_{oc} s suggest strong propensity to bind to soil, resulting in significantly retarded transport of these chemicals to groundwater. Once in the groundwater system, the high K_{oc} s indicate that movement of the chemicals will again be significantly retarded relative to groundwater flow.

The remaining three organic chemicals - 4-methyl-2-pentanone; 2-chlorophenol; and dichlorobenzenes - fall in between the first two groups with regard to environmental mobility.

The chemical 4-methyl-2-pentanone can be characterized as having moderate vapor pressure, moderate water solubility, a low HL constant, and a low K_{oc} . Consequently, volatilization of this contaminant is important in surface soil, whereas only moderate transport to groundwater will occur. In addition, the low K_{oc} , low HL constant, moderate water solubility, and moderate vapor pressure indicate that neither volatilization from surface soils nor partitioning to sediment will predominate.

The chemical 2-chlorophenol is characterized by a low vapor pressure, high water solubility, low HL constant, and a moderate K_{oc} . Consequently, volatilization from surface soils will occur at a slow

rate. Moderately retarded rates of infiltration to groundwater and transport in groundwater are also indicated by the properties listed above for 2-chlorophenol. These properties also indicate that partitioning to sediments is an important factor.

Dichlorobenzenes can be characterized as having high water solubilities, moderate vapor pressures, high HL constants, and high K_{oc} s. These properties indicate that volatilization is an important pathway from surface soil. A mixture of volatilization from surface water and partitioning to sediment is expected for the dichlorobenzenes. The high K_{oc} indicates that dichlorobenzenes will be subject to relatively high retardation and slow transport to groundwater. Based on the above data, Table 6-10 summarizes transport pathways for the contaminants of concern at the DCP sites.

Table 6-11 presents the generalized persistence values for organic contaminants of concern. These persistence values reflect the rate at which organic chemicals will break down in the environment and represent values used for HRS scoring. Although some chemicals exhibit the same persistence characteristics in all media, some chemicals are more persistent in certain media. For example, some PAHs are sensitive to photochemical degradation by ultraviolet light and degrade rapidly in the atmosphere. PAHs are generally persistent in sediment or soil. Similarly, some chemicals may be affected by biological or chemical activity in soils or water, depending upon conditions.

All four metals (arsenic, cadmium, lead, and nickel) are regarded as persistent in all media based upon their elemental nature. Many of the volatiles for which data were found can be characterized as not persistent. However, four of the volatiles (trans-1,2-dichloroethene; tetrachloroethene; 1,1,1-trichloroethane; and trichloroethene) are biodegraded primarily by a series of dechlorination steps to the human carcinogen vinyl chloride (Smith and Dragun 1985). The biotransformation process is depicted in Figure 6-1. Most chlorinated semivolatiles and PAHs can be classified as persistent. The PCBs are generally highly persistent in all media, with only the lower chlorinated (and generally less toxic) congeners subject to slow degradation.

Table 6-10

TRANSPORT PATHWAYS OF CONCERN FOR ORGANIC CONTAMINANTS OF
CONCERN FOR THE DEAD CREEK SITES

Chemical Name	Volatilization from Surficial Soil			Soil Transport to Groundwater			Adsorption to Soil			Volatilization from Surface Soil			Partitioning from Surface Water to Sediment		
	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
benzene	x			x					x	x					x
chlorobenzene		x			x			x			x			x	
2-chlorophenol		x			x			x			x			x	
dichlorobenzene (isomers)		x				x	x				x			x	
1,2-dichloroethane	x			x					x		x				x
trans-1,2-dichloroethene	x			x					x	x					x
2,4-dichlorophenol			x		x			x				x		x	
hexachlorobenzene			x			x	x					x	x		
4-methyl-2-pentanone		x		x					x		x				x
naphthalene			x			x	x					x	x		
PAHs			x			x	x					x	x		
PCBs			x			x	x					x	x		
pentachlorophenol			x			x	x			x			x		
phenol			x	x			x					x			x
tetrachloroethene	x				x			x		x					x
toluene	x				x			x	x						x
1,1,1-trichloroethane	x			x			x		x						x
trichloroethene	x			x											
2,4,6-trichlorophenol			x		x		x					x	x		

Source: Ecology and Environment, Inc. 1988.

Table 6-11

PERSISTENCE OF CONTAMINANTS OF CONCERN

Chemical Name	Persistence Value
<u>Volatile Organics</u>	
benzene*	1
chlorobenzene*	2
1,2-dichloroethane**	1
trans-1,2-dichloroethene	ND
4-methyl-2-pentanone	ND
tetrachloroethene	ND
toluene**	1
1,1,1-trichloroethane**	ND
trichloroethene**	2
<u>Semivolatile Organics</u>	
phenol	1
2-chlorophenol*	ND
2,4-dichlorophenol	ND
2,4,6-trichlorophenol**	3
pentachlorophenol**	3
hexachlorobenzene**	3
naphthalene*	1
dichlorobenzenes**	3
PCBs*	3
PAHs***	1-3

1 Somewhat persistent compounds.

2 Persistent compounds.

3 Highly persistent compounds.

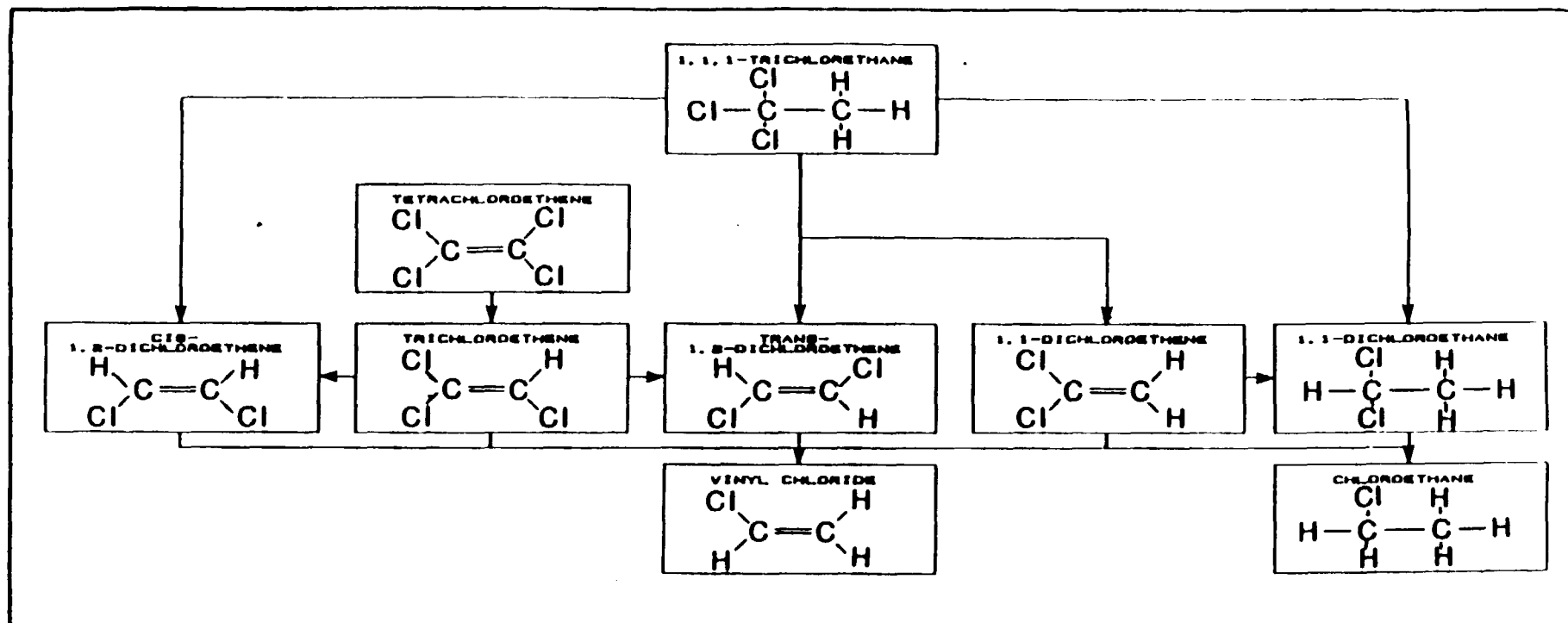
ND No data found.

* Uncontrolled Hazardous Waste Site Ranking System, A Users Manual, Published July 16, 1982, Federal Register, Table 4.

** Uncontrolled Hazardous Waste Site Ranking System, A Users Manual, Published July 16, 1982, Federal Register, Table 5.

*** Verschueren (1983).

Source: Ecology and Environment, Inc. 1988.



SOURCE: Smith & Dragum, 1984.

FIGURE 8-1 BIOTRANSFORMATION PATHWAYS FOR VARIOUS VOLATILE CHLORINATED PRIORITY POLLUTANTS IN SOIL AND GROUNDWATER

6.3.3 Overview of Transport Pathways, Receptors, and Exposure Routes

Five media represent potential sources of human exposures and potential adverse environmental impacts: air, soil, groundwater, surface water, and sediments. The public may be affected through exposure routes of inhalation, ingestion, or dermal contact with a contaminated release from these media. The potential human exposure routes are presented on Table 6-12. Figure 6-2 illustrates the potentially significant transport pathways for exposure to contaminants.

6.3.4 Selection of Transport Pathways/Exposure Routes of Concern

6.3.4.1 Introduction

Not all of the transport pathways/exposure routes are significant, however, because either the pathways are not complete (i.e., humans or aquatic life are not exposed), or alternatively, potential receptors are at locations far removed from contaminant sources, thereby minimizing chemical concentrations at the exposure location.

This discussion will examine the various potential pathways and identify those pathways of primary concern for HRS scoring and any endangerment assessment. Pathways via each of the five media will be examined. Table 6-13 presents a summary of the media contaminated at each of the DCP sites and creek sectors. Each of these media will be examined for transport pathways/exposure routes.

6.3.4.2 Soil-Related Transport Pathways/Exposure Routes

Surface Soil

Surface soils were examined at Sites G and J during the current investigation and Sites Q and R during previous investigations. Surface soil contamination was detected at all four sites.

The extensive elevated contamination of surface soils at Site G provides a source for transport. Transport pathways/exposure routes for contaminated surface soils at Site G are:

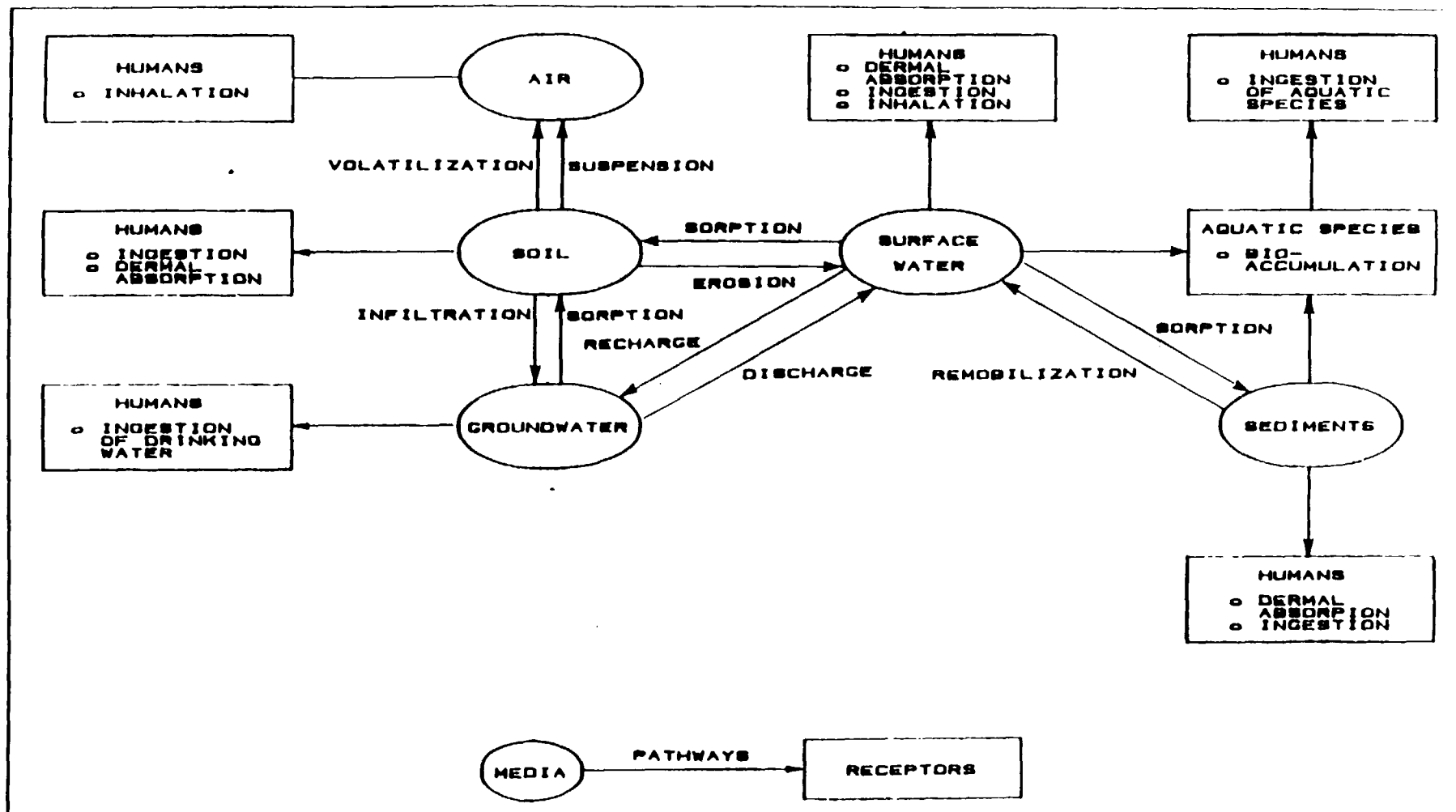
- Transport of contaminated runoff to adjacent property and/or Dead Creek;

Table 6-12

POTENTIAL HUMAN EXPOSURE ROUTES

Release Medium	Release Mechanism	Release Source	Human Exposure Route
Air	Volatilization	Contaminated soil	Inhalation
		Surface water	Inhalation
	Fugitive dust generation	Contaminated soil	Inhalation, ingestion
Surface Water	Surface runoff	Contaminated soil	Dermal contact, ingestion of water or aquatic species.
		Dead Creek overflow	Dermal contact, ingestion
	Ground Water Seepage	Contaminated ground water	Dermal contact, ingestion
Groundwater	Site leaching	Contaminated soil	Ingestion, dermal contact
	Contaminant infiltration	Dead Creek sediment	Ingestion, direct contact
Soil	Surface runoff	Contaminated soil	Ingestion, dermal contact
	Overland flow	Contaminated soil/leachate	Dermal contact, ingestion
	Fugitive dust generation	Contaminated soil	Inhalation, dermal contact, ingestion
	Tracking	Contaminated soil	Dermal contact, ingestion
Sediment	Tracking	Contaminated sediment	Dermal contact, ingestion

Source: Ecology and Environment, Inc. 1988.



SOURCE: Ecology and Environment, Inc., 1988.

FIGURE 6-2 CONTAMINATION TRANSPORT PATHWAYS, RECEPTORS AND EXPOSURE ROUTES

Table 6-13

CONTAMINANT OF CONCERN CONTAMINATION IN MEDIA AT DCP SITES

Site	Soils		Groundwater	Surface Water	Sediment	Air
	Surface	Subsurface				
G	X	X	X			X
H		X	X			
I/CS-A		X	X	X	X	
J	X	X				
K		X				
L		X	X			
M					X	
N		X				
O		X	X			
P		X				
Q	X	X	X			X
R	X	X	X			
CS-B		X		X	X	
CS-C					X	
CS-D					X	
CS-E					X	

Source: Ecology and Environment, Inc. 1988.

- Direct dermal contact with surface contaminants;
- Transport off-site as fugitive dust or volatilized emissions;
and
- Transport to groundwater via rainwater infiltration.

There are no berms or other surface controls to prevent runoff of concentrated wastes or contaminated rainwater to agricultural land to the south, Creek Sector B to the east, drainage ditches to the north, and commercial land to the west. Public access to the site was only recently restricted when an emergency fence was erected in May 1987 in response to the limited, initial findings of this investigation (see Table 6-14). There is no protective cover over the site to prevent volatilization or fugitive dust emissions. Nor is there any cover to prevent contaminated rainwater infiltration into the groundwater. Field investigations conducted during this study verified surface soil contaminant releases to surface water (Creek Sector B), groundwater, and the air. Dermal contact incidents occurred prior to the erection of the emergency fence, when children on bikes and on foot were observed on Site G.

Surface contamination at Site J is limited to several metallic contaminants of concern. Transport pathways/exposure routes for contaminated surface soils at Site J are:

- Direct dermal contact of people having access to the site,
- Transport off-site in uncontrolled runoff,
- Transport to groundwater via rainwater infiltration, and
- Transport off-site as fugitive dust emissions.

The field investigations of Site J conducted under this study did not include sampling designed to verify releases of surface soil contaminants. Accordingly, each of the pathways/routes identified above remain as potential, with the exception of the direct dermal contact route. Employees on the site are subject to dermal contact with site contaminants. Access to the site is limited only by a fence around the

Table 6-14

SUMMARY OF THE ACCESSIBILITY OF SITES TO
THE GENERAL PUBLIC AND WORKERS

Site Designation	<u>Access to General Public</u>		<u>Access to Workers</u>		
	Restricted	Accessible	Not Applicable	Restricted+	Accessible
G	X*		X		
H		X	X		
I	X				X
J		X**			X
K		X	X		
L		X			X
M	X		X		
N	X			X	
O		X	X		
P		X			X
Q	X***				X
R	X			X	

* Access to Site G restricted due to the construction of a fence as a response action by USEPA.

** Site J is fenced, but has no other mechanism for restriction (open gates).

*** Pedestrian access to the south end of site Q is possible.

+ Worker access is limited to employees having keys to or conducting work at the property.

Source: Ecology and Environment, Inc. 1988.

site and an unguarded main gate. Accordingly, dermal exposure to contaminants may occur when unauthorized persons venture onto the site.

Surface contamination at Site Q included both organic and inorganic contaminants. Transport pathways/exposure routes for contaminated surface soils at Site Q are:

- Transport off-site to the Mississippi River or adjacent property in uncontrolled contaminated runoff;
- Volatilization and fugitive dust emissions;
- Infiltration of contaminated rainwater into the groundwater; and
- Dermal contact with surface soils/leachate on-site.

Field investigations conducted during this and previous investigations verified surface soil contaminant releases to adjacent properties via contaminated leachate runoff, to groundwater via infiltration, and to the off-site atmosphere via fugitive dust emissions. Access to portions of the site are uncontrolled and provide potential direct dermal contact.

Organic and inorganic surface soil contamination at Site R in the form of contaminated leachate was documented during a previous study (IEPA and E & E, 1981). Similarly to Site Q, transport pathways/exposure routes for Site R are:

- Transport off-site to the Mississippi River or adjacent property in uncontrolled contaminated runoff;
- Volatilization and fugitive dust emissions;
- Infiltration of contaminated rainwater into the groundwater; and
- Dermal contact with surface soils/leachate on-site.

During a previous investigation, contaminated leachate was observed being discharged on the west side of the site into the Mississippi

River. Although access to the site is generally limited by fencing to authorized personnel, direct dermal contact with the leachate by boaters landing on the embankment was possible but not observed. Although discharges of leachate to the Mississippi River are now obscured by the presence of riprap, discharges probably continue to occur. Direct dermal contact with the leachate is prevented by the riprap. Limited air emission investigations have not verified the presence or absence of air emissions. A clay cap has been constructed over the site. Assuming proper cap installation, volatilized and fugitive dust emissions would be expected to be limited. Although the presence of a clay cap limits precipitation and surface contaminant infiltration, contaminants present on the surface in leachate have been detected in groundwater at the site.

Subsurface Soil

The subsurface soil contamination identified at Sites G, H, I, J, K, L, N, O, P, Q, and R and Creek Sectors A and B provides sources of contamination for transport. Transport pathways/exposure routes for subsurface contaminants are:

- Transport to the groundwater;
- Dermal contact via excavation into wastes and contaminated subsurface soils; and
- Volatilization to the atmosphere.

Release of contaminants to the groundwater has been verified at Sites G, H, I, L, O, Q, and R. Groundwater sampling at the other sites was not within the scope of this project, nor has it previously been conducted. However, based upon groundwater investigation results at Sites G, H, I, L, O, Q, and R, release of contaminants in subsurface soils and wastes to groundwater at Sites J, K, N, and P and Creek Sectors A and B is expected. At Sites G, H, I, and R, contaminated waste is buried to a depth such that it is in direct contact with the groundwater. At the other sites, release to the groundwater requires

the precipitation infiltration/leaching process to occur. Since there is no impermeable cover at any of the sites, infiltration/leaching is probably occurring.

Direct dermal contact with subsurface wastes and soils could occur only during excavation activities at the sites. This exposure would primarily occur only during authorized construction activities. For sites with limited or no access restrictions, unauthorized excavation and exposure is possible.

Volatilization and off-gassing of organic subsurface contaminants is occurring at the sites where organic contamination was detected. This phenomenon is substantiated by high organic concentrations in soil gases at the sites. These soil gases are released to the atmosphere by volatilization on a steady-state basis. Emissions of volatilized subsurface contaminants were not investigated during this or previous studies. Emissions may be at a rate which will produce no quantifiable concentrations in the breathing zone on or near the sites.

6.3.4.3 Groundwater-Related Transport Pathways/Exposure Routes

Groundwater contamination was examined at Sites G, H, I, L, O, Q, and R during the current and previous investigations of the DCP area. Contamination was detected at various levels at each of the sites.

There are two groundwater-related transport pathway/exposure routes for the DCP sites:

- Ingestion, inhalation of, or dermal contact with groundwater contaminants from private wells in or near the study area, and
- Transport to surface waters (Mississippi River).

As described in Sections 2.4 and 2.5, groundwater is used by many residents and industries in and near the DCP study area. Five residences on Judith Lane immediately south of Area 1 have private wells. While most of these wells are used for lawn and garden watering, one well is occasionally used as a source of drinking water. In addition, there are approximately 50 wells in the DCP area, as well as an unknown number of residential wells in the Schmids Lake area approxi-

mately 3 miles southwest of Area 1. The presence of organic and inorganic contaminants in groundwater samples taken from private wells along Judith Lane and at Clayton Chemical Co. property verifies the exposure route.

Field investigations of the DCP area during this and previous studies evaluated the connection between groundwater and surface waters. As discussed in Section 4.1.3.3 of this report, investigations verified the general movement of groundwater to the west and west-southwest and discharge of groundwater to the Mississippi River when the river stage was lower than the DCP area groundwater head. Discharge of groundwater to Dead Creek surface water was not observed. As discussed in Section 5, estimates were made of rates of groundwater movements, concentrations, and contaminant loadings to the Mississippi River. Based upon sampling data and groundwater modeling, contaminated groundwater from Sites R and Q is currently being discharged to the Mississippi River. Investigations indicate that discharges from these sites will continue and that contaminated groundwater from the other sites will also occur over time.

6.3.4.4 Sediment-Related Transport Pathways/Exposure Routes

Sediment samples from Creek Sectors A, B, C, and D, and Site M were examined during this investigation. No sediment samples were collected from the Mississippi River. Contamination of sediments in Creek Sectors A, B, C, and D, and at Site M was verified by this investigation. Contamination of sediments in Creek Sector E was verified during a previous investigation (IEPA 1980). Contamination of the Mississippi River sediments from contaminant discharges of DCP groundwater and leachate runoff from Sites Q and R is known to be occurring, but has not been verified by sampling.

Sediment-related transport pathway/exposure routes for all creek sectors, Site M, and Mississippi River sediments are :

- Dermal exposure or ingestion;
- Ingestion of recreationally or commercially supplied contaminated Mississippi River aquatic life; and

- Infiltration of contaminants to groundwater from Dead Creek and Site M sediments.

Direct dermal exposure to contaminated sediments can readily occur at Creek Sectors C, D, and E where access is unrestricted and children have been observed playing (see Table 6-15). Exposure to Creek Sectors A and B and Site M sediments is restricted by property or emergency response fencing which surrounds the areas. Although only a potential pathway until verified, access to contaminated Mississippi River sediments is unrestricted and easy during low river stages. Ingestion exposure to contaminated aquatic life is a potential but unverified pathway because a detailed site-specific aquatic life sampling investigation has not been undertaken. A Food and Drug Administration (FDA) study of Mississippi River fish identified the highest levels of chlorobenzene residue present in carp and sucker fish caught "near a chemical waste disposal site at Sauget, Illinois" (Yuravecz and Martin 1983). More study would be required to verify the pathway. Transport of contaminants from Dead Creek and Site M sediments to the groundwater via leaching and infiltration is expected based upon the physical properties of the contaminants and the geologic and hydrologic setting.

6.3.4.5 Surface Water-Related Transport Pathways/Exposure Routes

Surface water samples from Creek Sectors A, B, C, and D, and Site M were examined during this investigation. No samples were collected from the Mississippi River. Surface water contamination was detected in Creek Sectors A, B, C, D, and Site M. Contamination of the Mississippi River is known to be occurring through transport of contaminants present in DCP area groundwater and through leachate runoff from Sites Q and R.

Contamination of fish in the Mississippi River has also been documented as a result of various FDA and IEPA studies. According to several undocumented reports, U.S. EPA also initiated an investigation (caged fish study) to determine exposure to aquatic life in the river. Apparently, fish populations in a location adjacent to Site R were unable to survive, and the study was postponed. Specific information concerning this study has not been located to date.

Table 6-15

SUMMARY OF THE ACCESSIBILITY OF DEAD CREEK SURFACE
WATER AND SEDIMENTS TO THE GENERAL PUBLIC AND WORKERS

Surface Water/ Sediment Area	Access to General Public			Access to Workers			
	Restricted	Accessible	Estimated Pop. Exposed*	Not Applicable	Restricted	Accessible	Estimated Pop. Exposed
CS-A	X		NA			X	Unknown
CS-B	X		NA	X			NA
CS-C		X	8,000	X			NA
CS-D		X	12,000	X			NA
CS-E		X	16,000	X			NA
CS-F		X	16,000	X			NA
Site M	X		NA	X			NA
Mississippi River		X	Unknown	X			NA

NA Not applicable, site access restricted.

* Estimated population within 1 mile of the site (based on 1980 U.S. Census figures and percentage of town area within 1 mile of site).

Source: Ecology and Environment, Inc. 1988.

There are several surface water-related transport pathway/exposure routes for Dead Creek and Mississippi River surface waters:

- Dermal, inhalation, or ingestion exposure of recreational users of the Mississippi River;
- Ingestion of contaminated municipal drinking water taken from Mississippi River;
- Exposure of aquatic life to contaminated Mississippi River water;
- Ingestion of commercially and recreationally supplied contaminated aquatic life from the Mississippi River; and
- Dermal, inhalation, or ingestion exposure of people to contaminated Creek Sectors A, B, C, D, and Site M.

Verification of contaminant release and receptor exposure via the first four of these transport pathway/exposure routes was not within the scope of the project. Accordingly each of these four pathways/routes remain as potential. Recreational and commercial use of the Mississippi River occurs immediately west and downstream of Sites Q and R, as does aquatic life habitation. The Mississippi River is also used for municipal water supplies up and downstream of the DCP area. However, because the nearest downstream municipal drinking water intake is located approximately 28 miles downstream of the project area and because of the dilution effects of the Mississippi River, the verification and quantification of any or all of these four exposure routes may be difficult and would require additional sampling, study, and modeling.

The exposure routes for surface water contaminants in Creek Sectors A and B, and Site M are mitigated by the access limitations which now exist as a result of fencing. Only site workers at Site I have access to Creek Sector A surface waters. Emergency fencing precludes easy access to Creek Sector B and Site M surface waters. Access and exposure

to Creek Sector C and D surface waters is uncontrolled and represents a verified direct exposure route.

6.3.4.6 Air-Related Transport Pathway/Exposure Routes

Air contamination was examined at Sites G and Q. Releases of fugitive dust and volatilized contamination from surface soils to the air at these sites provides a source for exposure routes.

The air-related transport pathway/exposure routes for Sites G and Q are:

- Inhalation of contaminated air, and
- Dermal or ingestion exposure to air-transported dust deposits.

Air sampling at property boundaries of Sites G and Q verified contaminant release and supports these transport pathway/exposure routes. Access to Site G is now limited as a result of the construction of an emergency response fence. Access to portions of Site Q remain uncontrolled. The limited amount of adjacent receptors and the distance to large, concentrated receptor locations may mitigate the impact of the air pathways/routes. Additional sampling, study, and modeling of receptor locations would be required for quantification of potential impact.

6.3.4.7 Summary of DCP Transport Pathway/Exposure Routes

Based upon the above discussion, contaminant transport pathway/exposure routes exist for surface and subsurface soils, groundwater, sediments, surface water, and air in the DCP area. These pathways/routes represent direct exposure to sources or indirect exposure via intermediate transport media. Some of the pathways/routes are verified as complete. Other pathways/routes remain classified as probable or potential because sampling to verify completion was not included in the scope of this study. Table 6-16 presents a summary of pathways/routes discussed and the extent to which investigations support completion for each pathway/route.

It should be noted that additional pathways/routes may be present in the project area. For instance, the potable water line which crosses

Table 6-16

SUMMARY OF DCP CONTAMINANT TRANSPORT PATHWAY/EXPOSURE ROUTE ASSESSMENT

Media/Pathway	Pathway Completion Status (By Source)		
	Verified Current or Previous	Not Verified but probable*	Not Verified But potential**
<u>SOIL-RELATED</u>			
Direct Contact	G, J, Q		
Run-off	G, Q, R	J	
Dust/volatilized emissions	G, Q	J	H, I, K, N, O, P, Q, R
Infiltration to Groundwater	G, H, I, L, O, Q, R	J, K, M, N, P	
<u>GROUNDWATER-RELATED</u>			
Direct ingestion/inhalation/dermal contact	G, H, I, L, O, Q, R	J, K, M, N, P	
Transport to Mississippi River	G, H, I, L, O, Q, R	J, K, M, N, P, CS-A, CS-B, CS-C, CS-D CS-E	
<u>SEDIMENT-RELATED</u>			
Direct dermal/ingestion contact	CS-B, CS-C, CS-D, CS-E		
Ingestion via contaminated aquatic life (Mississippi River)			All sites
Infiltration to groundwater		CS-A, CS-B, CS-C CS-D, CS-E, Site M	
<u>SURFACE WATER-RELATED</u>			
Direct dermal/inhalation/ingestion contact	CS-B		CS-A (Site I workers and all sites)
Ingestion via municipal water supply			All sites
Ingestion via contaminated aquatic life			All sites
<u>AIR-RELATED</u>			
Inhalation of contaminated air		G, Q	H, I, J, K, N, O, P, R
Dermal/ingestion of air transported Contaminants		G, Q	J

* Pathways are classified as probable if substantial investigation derived information indicates a completed pathway exists, but that verifying samples have not been included in any investigation to date.

** Pathways are classified as potential if investigation derived information suggests that a completed pathway may exist, but that several verifying data items have not been included in any investigation to date.

Source: Ecology and Environment, Inc. 1988.

Site P may be impacted by groundwater and/or surficial contamination. Because discussions on such pathways would be entirely dependent on empirical data, they have not been included in this section.

The significance of each pathway/route will be evaluated by the generalized assessment procedures under the forthcoming HRS 2 model. If justified, further evaluation of the pathways/routes may be completed as part of a detailed endangerment assessment.

6.4 TOXICITY ASSESSMENT

6.4.1 Standards and Criteria

According to the transport pathway/exposure route assessment in Section 6.3.4, each of the media (soils, groundwater, surface water, sediments, and air) represents a potential risk to human health and/or aquatic life. The following subsections contain a discussion of the standards and criteria which may be applicable to each media.

6.4.1.1 Soil and Sediment Standards and Criteria

Strictly speaking, there are no standards or criteria for the contaminants of concern in soils at the DCP sites. For instance, cleanup of PCB wastes under the Toxic Substances Control Act (TSCA) applies only to disposal or spills after 1977. The Centers for Disease Control (CDC) has developed an advisory level of 1 ppb (ug/kg) 2,3,7,8-TCDD for Times Beach, Missouri residential soils. While useful for reference, this advisory is not applicable to soils at the DCP sites, which are not residential areas.

6.4.1.2 Groundwater Standards and Criteria

Two sets of drinking water standards and criteria are potentially useful in evaluating the groundwater contamination at the Dead Creek sites:

- EPA enforceable maximum contaminant limits (MCLs), non-mandatory proposed MCLs, or non-mandatory proposed or final maximum contaminant limit goals (MCLGs); and
- EPA non-mandatory health advisories (HAs).

Depending upon the stage of rulemaking, EPA may have issued final MCLs, proposed MCLs, final MCLGs, or proposed MCLGs for a particular chemical. Proposed and final MCLGs are nonenforceable health goals issued during the first stages of rulemaking. Proposed and final MCLGs are set at 0 for substances evaluated as probable human carcinogens (Group A or B) according to EPA weight-of-evidence carcinogenicity criteria. For chemicals falling in other categories, MCLGs are usually set based on chronic toxicity, or in the absence of suitable chronic data, non-chronic data using the reference dose (RfD) threshold-based approach. Proposed and final MCLs are established as close to MCLGs as feasible, taking into account cost, availability of treatment technology, and analytical methods (EPA 1985b; 1987a).

EPA drinking water HAs have been developed from data describing noncarcinogenic end points of toxicity using RfDs. HAs do not incorporate quantitatively any potential carcinogenicity. Consequently, for chemicals classified as carcinogens, the HAs should be applied only to assess non-chronic toxicity end points, with the understanding that carcinogenicity must be addressed separately (EPA 1985d). HAs for adults are developed using the RfDs. Derivation of HAs for children assumes a standard 10 kilogram weight and 1 liter per day drinking water consumption. For those chemicals which are classified as human or probable human carcinogens, non-zero 1-day, 10-day, and longer-term HAs may be derived, with appropriate caveats. However, EPA has not developed and does not recommend using HAs for lifetime (chronic) exposures to carcinogens.

Drinking water standards and health advisory criteria for contaminants of concern at the DCP sites are presented in Table 6-17.

6.4.1.3 Surface Water Standards and Criteria

Under the jurisdiction of the Clean Water Act, EPA has issued advisory ambient water quality criteria for the protection of aquatic life and human health. These criteria have been issued for use by the states in establishing industrial surface water effluent standards. The first set of these criteria, the ambient water quality criteria (AWQC), have been issued for both acute and chronic exposures for the protection of freshwater and marine aquatic life. The freshwater standards are

Table 6-17

DRINKING WATER STANDARDS AND HEALTH ADVISORY CRITERIA FOR CONTAMINANTS
OF CONCERN AT THE DEAD CREEK SITES
(in ug/L)

Chemical	Standards EPA MCL	Health Advisories					
		EPA MCLG	One-day 10 kg	Ten-day 10 kg	Longer-term		Lifetime 70 kg
arsenic	50	50(p)	50	50	50	50	50
benzene	5	0	233	233	--	--	NA
cadmium	10	5(p)	43	8	--	--	5
chlorobenzene	--	--	1,800	1,800	9,000	30,000	3,150
2-chlorophenol	--	--	--	--	--	--	--
1,2-dichloroethane	5	0	740	740	740	2,600	NA
1,2-dichlorobenzene	--	620(p)	8,930	8,930	8,930	31,250	3,125
1,3-dichlorobenzene	--	--	8,930	8,930	8,930	31,250	3,125
1,4-dichlorobenzene	75	75	10,700	10,700	10,700	37,500	3,750
trans-1,2-dichloroethene	--	70(p)	2,720	1,000	1,000	3,500	350
2,4-dichlorophenol	--	--	--	--	--	--	--
hexachlorobenzene	--	--	50	50	50	175	--
lead	50	20(p)	--	--	20 ug/day	20 ug/day	20 ug/day
4-methyl-2-pentanone	--	--	--	--	--	--	--
nickel	--	--	--	1,000	--	--	350
PAMs	--	--	--	--	--	--	NA
PCBs	--	0(p)	--	--	1 (child)* 35 (adult)*	--	NA
pentachlorophenol	--	200(p)	1,000	300	300	1,050	1,050
phenol	--	--	--	34,000	--	--	--
tetrachloroethane	--	--	--	34,000	1,940	6,800	NA

Table 6-17 (Cont.)

Chemical	Standards EPA MCL	Health Advisories				Longer-term		Lifetime
		EPA MCLG	One-day 10 kg	Ten-day 10 kg		10 kg	70 kg	70 kg
toluene	--	2,000(p)	18,000	6,000		--	--	10,800
1,1,1-trichloroethane	200	200	140,000	35,000		35,000	125,000	1,000
trichloroethene	5	0	--	--		--	--	NA
2,4,6-trichlorophenol	--	--	--	--		--	--	NA

-- No standard or criterion.

NA Not applicable.

(p) Proposed.

Source: EPA(1986a).

directly applicable to the Mississippi River. Table 6-18 presents the ambient water quality criteria for both freshwater and marine aquatic environments.

EPA ambient water quality criteria have also been derived, as appropriate, for carcinogenic or noncarcinogenic human health end points (EPA 1980a). For noncarcinogens, criteria have been developed based on the RfD approach. EPA has developed criteria for carcinogens using linear or linearized multistage models to estimate drinking water levels corresponding to excess lifetime cancer risk estimates derived on the basis of estimated lifetime consumption of drinking water (2 liters/day) and aquatic species (6.5 grams fish and shellfish/day) taken from waters containing the corresponding contaminant concentration. These human health ambient water quality criteria were developed prior to 1980 and published in 1980 (EPA 1980a; 1986g). Since then, EPA may have revised its conclusions not only qualitatively as to the hazards presented, but also quantitatively as to the risks associated with chemical exposures and requisite exposure levels. Consequently, the water quality criteria should only be used where not superseded by EPA health advisories, drinking water standards, or State of Illinois standards.

Table 6-18 also summarizes the human health Ambient Water Quality Criteria (AWQC) for the chemical contaminants of concern. In addition, the Food and Drug Administration (FDA) has issued a third set of criteria, which outlines tolerance limits for PCBs in food. These criteria are listed in Table 6-19.

6.4.1.4 Air Standards and Criteria

There are no ambient air standards or criteria specific to PCBs or most of the other contaminants of concern. PCBs were the contaminant of concern which was detected in significantly higher concentrations in the air downwind of Sites G and Q than upwind. Occupational Safety and Health Administration (OSHA) Workplace Standards for PCBs and other contaminants of concern exist; however, these standards are not meant to be applied directly to the ambient environment. A contaminant-specific endangerment assessment would need to be conducted to establish meaningful air standards.

Table 6-18

SUMMARY OF EPA AMBIENT WATER QUALITY CRITERIA
FOR CONTAMINANTS OF CONCERN FOR THE DCP SITES*

Chemical	Aquatic Life Criteria (ug/L)				Human Health Criteria (ug/L)		
	Freshwater Acute	Freshwater Chronic	Marine Acute	Marine Chronic	Water and Fish Ingestion	Fish Consumption Only	Organoleptic †††
arsenic (pentavalent)	850***	48***	2,319***	13***	--	--	--
arsenic (trivalent)	360	190	69	36	--	--	--
benzene	5,300***	--	5,100***	70***	0.66 †	40 †	--
cadmium	3.9**	1.1**	43	93	10	--	--
chlorobenzene	--	--	--	--	488	--	20
2-chlorophenol	--	--	--	--	--	--	--
1,2-dichloroethane	118,000	20,000	113,000	--	0.94†	243	--
dichlorobenzenes	1,120***	763***	1,970***	--	400	2,600	--
trans-1,2-dichloroethene	11,600***	--	224,000***	--	--	--	--
2,4-dichlorophenol	2,020***	365***	--	--	3,090	--	--
hexachlorobenzene	--	--	--	--	0.72 ng/L †	0.74 ng/L †	--
lead	82**	3.2**	140	5.6	50	--	--
4-methyl-2-pentanone	--	--	--	--	--	--	--
nickel	1,800**	96**	140	7.1	13.4	100	--
PAHs	--	--	300***	--	2.8 ng/L †,††	31.1 ng/L †,††	--
PCBs	2	0.014	10	0.03	0.079 ng/L †	0.079 ng/L †	--
pentachlorophenol	55***	3.2***	53***	34***	1,010	--	30
phenol	10,200***	2,560***	5,800***	--	3,500	--	300
tetrachloroethene	5,280***	840***	10,200***	450***	0.8	8.85	--
toluene	17,500***	--	6,300***	5,000***	14,300	424,000	--
1,1,1-trichloroethane	180,000***	--	--	31,200***	18,400	1.03 g/L	--

Table 6-18 (Cont.)

Chemical	Aquatic Life Criteria (ug/L)				Human Health Criteria (ug/L)		
	Freshwater Acute	Freshwater Chronic	Marine Acute	Marine Chronic	Water and Fish Ingestion	Fish Consumption Only	Organoleptic †††
trichloroethene	45,000***	21,900***	2,000***	—	2.7†	80.7 †	—
2,4,6-trichlorophenol	--	970***	--	—	1.2†	3.6 †	2.0

- No criteria.

* Source: EPA (1986g).

** Hardness dependent criterion (100 mg/L hardness used to derive criteria).

*** Insufficient data available to develop criteria. Value presented is the lowest observed effect level (LOEL).

† Human health criteria for carcinogens reported for three estimated risk levels. Value presented is the estimated 10^{-6} risk level.

†† Based on animal data for benzo(a)pyrene.

††† Derived based on taste and odor characteristics.

Table 6-19

FOOD AND DRUG ADMINISTRATION
TEMPORARY TOLERANCES FOR PCBs IN FOOD

Food	Tolerance (ppm)
Milk (fat basis)	1.5
Dairy products (fat basis)	1.5
Poultry (fat basis)	3
Eggs	0.3
Fish and shellfish (edible portion)	2

Source: 29 CFR 109.3.

6.4.2 Classification of Chemicals as Carcinogens or Noncarcinogens

Based on significantly different dose-response curves, resulting in significantly different risk estimates, chemicals are often divided into two categories--carcinogens and noncarcinogens. The term carcinogen means any chemical for which there is sufficient evidence that exposure may result in continuing uncontrolled cell division (cancer) in humans and/or animals. The term noncarcinogen means any chemical for which the data are either negative or are insufficient to evaluate potential carcinogenicity. These categorizations are not static. Rather, at any time, additional data may become available which would shift the weight of evidence so that a noncarcinogen would be reclassified as a carcinogen, or a carcinogen as a noncarcinogen. Risk assessments for most carcinogens are based on the concept that any exposure presents an infinite risk, or high probability, of cancer to man. As contaminant levels decrease, however, there is a point at which concern for carcinogenic risk becomes vanishingly small. Risk assessments for noncarcinogens are based on the concept that there exists a threshold exposure level, below which adverse health consequences do not occur.

In this report, chemicals have been classified as carcinogens or noncarcinogens based on EPA weight-of-evidence criteria which take into account the quality and adequacy of the experimental data and kinds of responses. Table 6-20 summarizes the five EPA weight-of-evidence categories in current use.

According to EPA guidelines, chemicals in groups A or B (B_1 or B_2) are considered human carcinogens or probable human carcinogens and are subject to nonthreshold carcinogenic risk estimation procedures. Chemicals in group C are considered possible human carcinogens and may or may not be subject to carcinogenic risk estimation procedures, depending upon the quality of the available data. Chemicals in groups D or E are considered noncarcinogens and are subject to standard threshold-based toxicological risk estimation procedures. Tables 6-21 and Table 6-22 present the carcinogenic classification for the contaminants of concern.

Toxicological profiles for all contaminants of concern were prepared and are presented in Appendix F of this report. These profiles take into account all the aforementioned criteria for assessing risk to

Table 6-20

FIVE EPA CATEGORIES FOR EVALUATING THE
EVIDENCE OF CHEMICAL CARCINOGENICITY

Group	Description
Group A	Human Carcinogen - sufficient evidence from epidemiological studies
Group B	Probable Human Carcinogen -
Group B ₁	o At least limited evidence of carcinogenicity to humans
Group B ₂	o Usually a combination of sufficient evidence for animals and inadequate data for humans
Group C	Possible Human Carcinogen - limited evidence of carcinogenicity in animals in the absence of human data
Group D	Not Classifiable - inadequate human and animal evidence of carcinogenicity
Group E	Evidence of Noncarcinogenicity for Humans - no evidence of carcinogenicity in at least two adequate animal tests in different species or in both adequate epidemiological and animal studies

Source: EPA 1986a

Table 6-21

SUMMARY OF EPA CARCINOGENICITY CATEGORIES,
ESTIMATED CANCER POTENCIES, AND REFERENCE DOSES FOR
CONTAMINANTS OF CONCERN FOR THE DCP SITES *

Chemical	Oral Route			Inhalation Route		
	EPA Carcinogenicity Category	Estimated Cancer Potency (mg/kg/day)	Reference Dose (mg/kg/day)	EPA Carcinogenicity Category	Estimated Cancer Potency (mg/kg/day) ⁻¹	Reference Dose (mg/kg/day)
arsenic	A	1.5	NA	A	50	NA
benzene	A	0.052	NA	A	0.026	NA
cadmium	D	NA	0.00029	B ₁	6.1	NA
chlorobenzene	D	NA	0.027	D	NA	0.0057
2-chlorophenol	D	NA	NA	D	NA	ND
1,2-dichlorobenzene	D**	NA	0.089***	ND	ND	ND
1,3-dichlorobenzene	D**	NA	0.089***	ND	ND	ND
1,4-dichlorobenzene	C**	ND**	0.1**	ND	ND	ND
1,2-dichloroethane	B ₂	0.091	NA	B	0.035	
trans-1,2-dichloroethene	C	0.58	ND	C ²	1.16	ND
2,4-dichlorophenol	D	NA	0.003	ND	ND	NA
hexachlorobenzene	B ₂	1.69	NA	ND	ND	ND
lead	D	NA	0.0014	D	NA	0.00043
4-methyl-2-pentanone	D	NA	0.05	D	NA	ND
nickel	D	NA	0.02	A	1.19	NA
PAHs	See Table 6-22					
PCBs	B ₂	7.0†	NA	B ₂	ND	ND
pentachlorophenol	D	NA	0.03	D	NA	ND
phenol	D	NA	0.11	D	0.02	NA

Table 6-21 (Cont.)

Chemical	Oral Route			Inhalation Route		
	EPA Carcinogenicity Category	Estimated Cancer Potency (mg/kg/day)	Reference Dose (mg/kg/day)	EPA Carcinogenicity Category	Estimated Cancer Potency (mg/kg/day) ⁻¹	Reference Dose (mg/kg/day)
tetrachloroethene	B ₂	0.051	NA	B ₂	0.0017	NA
toluene	D	NA	0.3	D	NA	1.5
1,1,1-trichloroethene	D	NA	0.54	D	NA	6.3
trichloroethene	B ₂	0.011	NA	B ₂	0.0046	NA
2,4,6-trichlorophenol	B ₂	0.0190	NA	B ₂	NA	NA

Key:

NA Not applicable.

ND Not derived by EPA.

* Unless otherwise footnoted, data extracted from EPA (1986a).

.. EPA (1987a).

... EPA (1985d).

† EPA (1987e).

Table 6-22

EPA CARCINOGENICITY CATEGORIZATION FOR ORAL
AND INHALATION ROUTES OF EXPOSURE FOR THE 15
PRIORITY POLLUTANT POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)*

EPA Carcinogenicity Classifications *				
Compound	Inhalation	Estimated Cancer Potency (mg/kg/day) ⁻¹	Oral	Estimated Cancer Potency (mg/kg/day) ⁻¹
acenaphthene	D	NA	D	NA
anthracene	D	NA	D	NA
benzo(a)anthracene	B ₂	ND**	B ₂	ND**
benzo(b)fluoranthene	B ₂	ND**	B ₂	ND**
benzo(k)fluoranthene	D	NA	D	NA
benzo(g,h,i)perylene	D	ND	D	NA
benzo(a)pyrene	B ₂	6.1**	B ₂	11.5*
chrysene	B ₂	ND**	B ₂	ND**
dibenzo(a,h)anthracene	B ₂	ND**	B ₂	ND**
fluoranthene	D	NA	D	NA
fluorene	D	NA	D	NA
indeno(1,2,3-cd)perylene	C	ND**	C	ND**
phenanthrene	D	NA	D	NA
pyrene	D	NA	D	NA

ND Not derived.

NA Not applicable.

* Unless otherwise footnoted, classifications and potencies taken from EPA 1986a).

** EPA has typically assumed that the carcinogenic potency estimate derived from the benzo(a)pyrene animal data can be applied to all category B or A PAHs. However, reanalysis of various PAH potency values is pending.

health and the environment. These profiles provide a basis for quantifying risk and may be applied to any endangerment assessment for the DCP area.

6.5 SUMMARY

Based on the discussion in this section, the wastes and contamination at the DCP sites provides multiple sources of contaminants to be released to the environment. Contained within these sources are numerous high concentrations of contaminants which, because of their mobility, persistence, and toxicity, represent a potential threat to public health and the environment. The measure of the potential threat is controlled by the existence or absence of pathways/routes to receptors. The assessment of pathways/routes for contaminants present in the DCP area first identified possible pathways/routes and then determined pathways/routes which, through field investigations, were: verified as complete; unverified but probable; or unverified but potential. Environmental standards and criteria (primarily water-related) were identified. Examination of the groundwater contaminant concentrations detected at many of the sites revealed many contaminants in excess of or approaching standards and criteria. The contaminants were assessed for their status as carcinogens. These ratings ranged from human carcinogens to non-carcinogens.

Based upon this exposure assessment, an assessment of the sites can readily be undertaken when the HRS 2 model is promulgated.

7. FINDINGS AND CONCLUSIONS

7.1 INTRODUCTION

This section presents the findings of the background data search and field investigations for the DCP and the subsequent conclusions concerning the nature and extent of contamination at the DCP sites and creek sectors. These findings and conclusions are intended to be used to support future Hazard Ranking System (HRS) scoring efforts and to support future remedial activities at the sites.

7.2 FINDINGS

7.2.1 Background Information and Site Features

The findings of the background data search provide a historical perspective of the DCP sites and summarize site features. The findings are intended to support subsequent HRS scoring by showing that disposal activities at the various sites are related by common ownership, operators, and generators, thereby substantiating site aggregation. The DCP sites are aggregated into three groupings: Area 1 (Sites G, H, I, and L, and CS-A and CS-B), Area 2 (Sites O, Q, and R), and Peripheral Sites (Sites J, K, M, N, and P and CS-C and CS-D).

In general, waste disposal activities at the DCP sites followed a historical progression from the Area 1 sites to the Area 2 sites (see Section 2). For the most part, disposal activities, if any, at the peripheral sites appear to be unrelated to those at Area 1 and Area 2 sites. Findings of the background data search are presented under separate headings for the three site aggregates.

- Previous investigations and sampling have indicated common contaminants, including phenols, chlorophenols, chlorobenzenes, PAHs, and PCBs at all DCP Area 1 (Sites G, H, I, and L; CS-A and CS-B) and Area 2 (Sites O, Q, and R) sites and creek sectors. All of these compounds were listed on the waste inventories submitted by Monsanto for Site R, or are manufacturing byproducts of compounds listed on the inventories.
- Previous investigations have indicated general groundwater contamination across the majority of the DCP area. Several of the DCP sites, including Sites G, H, I, L, O, Q, and R, have previously been implicated as source areas for groundwater contamination in the area.
- Chemical waste material is present on the surface only at Site G. Slag, casting sand, and other industrial refuse/fill is present on the surface at Sites J, N, and P. The remaining project sites were subsurface disposal areas or impoundments that have since been covered with various fill material.

Area 1

- Historical aerial photographs show a single excavation across current DCP sites H and I. The excavation was subsequently bisected by the construction of Queeny Avenue. A second pit was excavated at Site I after the initial pit was filled.
- Disposal activities at Sites G, H, and I occurred concurrently between the years 1940 and 1955. Each property was owned in whole or in part by Leo and Louise Sauget during the years of operation.
- Monsanto submitted CERCLA "Notification of Hazardous Waste Site" forms to USEPA in 1980 for the Sauget (Monsanto) Illinois Land-fill on Falling Springs Road in Sauget. The forms listed disposal of organics, inorganics, solvents, and unknown wastes, and indicated below-ground disposal of drums. The years of oper-

ation for the facility listed on the forms were unknown to 1957. The pre-1957 time frame corresponds with the time frame for activities at Sites H and I indicated by historical aerial photographs.

- Historical aerial photographs indicate evidence of waste material being discharged to CS-A before 1950. Staining is evident in photographs of CS-A since that time. Presently, only surface and roof drainage from the Cerro Copper Products Company plant is discharged into CS-A. Water in CS-A is currently directed to an interceptor at the north end of the Cerro property, and is eventually discharged to the Sauget Waste Water Treatment Plant. Water in CS-A is currently extremely discolored and oily, and dark staining is evident along the entire length of the creek bank. Flow from CS-A to the south is restricted by a blocked culvert under Queeny Avenue.
- Historical aerial photographs also show evidence of direct discharge of waste material to CS-B. Staining is currently evident in the northern one-half of CS-B. A rubbery material covers the creek bed in an area approximately 150 feet south of Queeny Avenue, substantiating reports that effluent from the Midwest Rubber Company was previously discharged to CS-B. Water is present in the northern one-half of CS-B only after periods of moderate to heavy precipitation. Water is present at all times in the southern one-half of CS-B. The entire length of CS-B is choked with vegetation. The vegetation restricts flow in the creek. CS-B and Site M are currently enclosed by a chain-link fence, which was constructed as a response to the high levels of contamination observed in CS-B during the 1980 IEPA investigation. Flow from CS-B to the remainder of Dead Creek is restricted by a blocked culvert under Judith Lane.

Area 2

- Disposal operations occurred concurrently at current DCP Sites Q and R. Historical aerial photographs indicate the presence of

liquid waste material at both sites. According to IEPA file information, both sites were operated by Sauget and Company.

- Monsanto Chemical Company owns the property which constitutes DCP Site R, and disposed of liquid chemical wastes at the site between the years 1957 and 1974. Monsanto submitted inventories of wastes disposed of at the site for the years 1968 and 1971 to IEPA, which listed specific chemical compounds and derivatives.
- The Sauget Waste Water Treatment Plant has processed effluent from Sauget industries since approximately 1965. Monsanto has been the largest single contributor to the plant since that time. Between the years 1965 and 1978, the treatment plant disposed of all or part of its clarifier sludge into a series of lagoons (current DCP Site O). The treatment plant has had a long history of contaminated effluent. Phenol, chlorobenzenes, aniline derivatives, PCBs, and mercury have consistently been detected in plant effluent.
- Previous investigations and sampling have indicated unrestricted flow of contaminated leachate and groundwater to the Mississippi River in the area of Sites Q and R. This discharge, in combination with the discharge of contaminated effluent from the Sauget Wastewater Treatment Plant, has led to a general degradation of water quality in the river, and has contaminated fish in the river. Food and Drug Administration fish sampling indicated the presence of contaminants from the DCP area in fish collected as far as 100 miles downstream (see Appendix A).

Peripheral Sites

- Historical aerial photographs show excavated areas at current DCP Sites J, K, M, and N. With the exception of Site M, which was investigated during IEPA's 1980 study, no file information was available for these sites.

- The larger of the two excavations at Site J has been partially filled with casting sand, slag, and demolition debris. This pit is excavated below the water table, and fill material is in contact with the groundwater. A triangular area to the northeast of the foundry buildings at Site J is also covered with casting sand, slag, and construction debris.
- The former pit at Site K was excavated on two separate occasions. The excavation was initially seen in the 1950 aerial photograph. This initial excavation was filled prior to 1962, as evidenced by the photographs. The same area was again excavated sometime prior to 1973, and a dark liquid or dark staining is evident in the photograph from that date. The excavation had again been filled by 1978. Site K is located adjacent to a small residential area.
- The excavation at Site M was initially seen in the aerial photograph from 1950. Water was evident in the pit in all except the 1955 photograph, suggesting hydraulic connection between the pit and groundwater at that time. However, water was again seen in the pit in 1962, when groundwater pumpage in the area reached a peak of approximately 36 million gallons per day. Site M is presently enclosed by a chain-link fence. Household debris is scattered across the bank of the pit in the northeast corner. Flow between the pit and the southern portion of CS-B occurs through a break in the creek bank near the southwest corner of Site M. No evidence of disposal activity in the pit was seen in historical aerial photographs, and the pit has remained essentially unchanged since it was initially excavated.
- The pit in the southwest corner of Site N was initially excavated sometime prior to 1950. The pit has been partially filled with construction debris, but the area remains below grade as compared with the surrounding topography. The property on which the pit is located is currently used by the H.H. Hall

Construction Company for equipment storage. The entire property is enclosed by a chain-link fence.

- Site P is a former IEPA-permitted landfill which was permitted to accept only non-chemical waste from Monsanto and filter cake waste from Edwin Cooper, Inc. (now Ethyl Corporation). Previous IEPA inspections indicated the disposal of chemical wastes and/or packagings at the site. Deep erosion channels are currently seen along the entire east and west perimeter of the site. The central portion of the site was not filled due to the presence of a potable water line in the area. A night club and parking area presently occupy approximately 3 acres in the southeast corner of the site. Access to the site is not restricted.
- Previous IEPA sampling of surface water and sediments in the creek indicated limited contamination as far south as CS-E (at the intersection of Routes 3 and 157). Access to the creek is not restricted south of CS-B, and children have been observed playing in and around the creek banks in CS-D.
- Dead Creek flows intermittently from CS-C to CS-E through a series of culverts and underground pipes. West of CS-E, the creek discharges into a wetland area. This area in turn discharges to the Prairie DuPont Floodway, located south of the Town of Cahokia. The floodway subsequently discharges to the Cahokia Chute of the Mississippi River. The creek bed is heavily vegetated along its length between CS-C and CS-E, and is often dry following extended periods without precipitation.

7.2.2 Water Resources

The findings of the water supply search are intended to be used to support the development of HRS scores for the aggregate site areas. These findings provide a summary of data applicable to the targets portion of the HRS model.

- Although the majority of residents in the DCP area utilize public water supplies for drinking water, many residents to the south of the DCP area rely on private well supplies. A review of IDPH files indicated that at least 50 homes in the general area have active wells that are used for drinking water and/or irrigation of gardens.
- Two separate rural areas, near East Carondolet and Schmids Lake, rely entirely on groundwater supplies for drinking water. Both areas are located outside of the distribution areas for public water supply systems.
- The nearest private well used for drinking water is located approximately 1/4-mile south of Site L, at 102 Judith Lane. Although this well is mainly used to water a garden, one of the owners often drinks the water from the well.
- Based on available information, other than the use of private wells for watering gardens, irrigational use of groundwater is limited to three wells in the Schmids Lake - East Carondolet area. Approximately 400 acres of farmland are irrigated by these wells.
- Public water supplies in the DCP area utilize a surface intake in the Mississippi River as the source of raw water. The intake, located at river mile 181 (approximately 3 miles north of the DCP area), is operated by the Illinois American Water Company (IAWC). IAWC distributes water to residents to the north of the DCP area, and sells water to other water companies and municipalities for distribution.
- The City of St. Louis and surrounding areas utilize intakes in the Mississippi, Missouri, and Meramec Rivers as sources of raw water. All of these intakes are located in upstream areas from the DCP sites.

- The nearest downstream intake in the Mississippi River is located at river mile 149, approximately 28 miles south of the DCP area. The Village of Crystal City, Missouri (population 4,000) utilizes a Ranney well adjacent to the river as a source of drinking water.
- The nearest downstream surface intake on the Illinois side of the Mississippi River is located at river mile 110, approximately 65 miles south of the DCP area. This intake supplies drinking water to residents in the Town of Chester and surrounding areas in Randolph County, Illinois.

7.2.3 Geophysical Surveys

This subsection summarizes the findings of geophysical investigations conducted at DCP Sites G, H, J, and L.

Site G

- The magnetometry survey at Site G showed that major magnetic anomalies cover most of the site north of the ridge located near the southern boundary of the site, indicating that ferrous metal objects may be buried throughout the disposal pit. Numerous open and decayed drums were observed along the east, south, and west borders of the site.
- Shallow EM survey results indicated three areas of relatively high intensity anomalies in the northeast corner, in the east-central portion, and the entire mounded area along the west perimeter of the site. Deep soundings indicated a significant anomaly covers most of the northern portion of the site.

Site H

- The results of the magnetometry survey indicate three large areas with major magnetic anomalies and two smaller localized areas with lower-intensity anomalies. These anomalies appear to be associated with one large fill or disposal pit.

- Results from shallow EM soundings (0 to 7.5-meter effective depth range) indicated three high-intensity anomalies which correlated with magnetic anomalies detected in the magnetometry survey. Similar anomalies were detected during intermediate soundings (5 to 15 meters). Deep soundings (12 to 30 meters) showed much lower conductivity readings over the entire site, indicating that disposal was generally limited to a depth of less than 15 meters.

Site J

- Several small anomalies were detected with both the magnetometry and EM instrumentation. However, on-site observations suggest that these small anomalies may be the result of buried slag or interference from steel casings and scrap metals which were found at the surface throughout the survey area.

Site L

- Results from the magnetometry study were inconclusive due to interferences from heavy construction equipment located at the site.
- EM survey results, using various coil alignments to obtain readings from various depths, showed no significant anomalies.

7.2.4 Geology and Soils

This subsection contains general findings regarding the DCP area followed by specific findings for each site.

- The upper 14 to 50 feet of the unconsolidated valley fill deposits found in the American Bottoms were investigated during the DCP study. The valley fill deposits are typically composed of two main formations which extend as deep as 120 feet in the DCP area.
- The Cahokia Alluvium is the uppermost formation and comprises thin, generally discontinuous beds of silt, clay, and silty

sand. In study area soil borings, an average of 13 to 20 feet of sandy silt and clay deposits was found overlying silty sands, which gradually grade into a fine- to medium-grained clean sand in lower portions of the formation.

- Underlying the alluvium is the Mackinaw member of the Henry Formation. The upper portion of the Henry Formation consists of light brown to gray fine- to coarse-grained sand which coarsens with depth. The literature indicates that bands of coarse gravel, cobbles, and occasional boulders are found at depths greater than 75 feet. These sand and gravel deposits directly overlie the Mississippian Age St. Genevieve Limestone.
- In the DCP area, differentiation of the Henry Formation and Cahokia Alluvium deposits is not possible on the basis of mineralogical and textural characteristics or on lithologic breaks. As a result, the Cahokia Alluvium appears to grade almost imperceptibly into the sand and gravel valley train deposits of the Henry Formation below.
- Other materials identified during the investigation include surficial fill materials consisting of silty clay, silt, sand, demolition debris, crushed gravel, fly ash, and cinders. One or more of these materials were found at every DCP site.
- Buried waste materials were found at Sites G, H, I, O, and Q during this investigation. These included sludges, liquids, and solids, together with refuse (e.g., wood and paper products) and stained or oily fill material. Based on a review of previous investigations and file information, similar materials were disposed at Site R.

Area 1

Site G

- At Site G, 3 to 12 feet of fill material was found overlying 15 to 25 feet of wastes. Wastes were found directly overlying

lower Cahokia or upper Henry Formation sands. These sands were found extensively stained below the waste material.

- The majority of waste material at Site G is presently below the water table, which averages 11 feet below ground surface. Waste materials were also found at the surface, particularly in the eastern half of the site, where two oily tar disposal areas are located.

Site H

- At Site H, 2.5 to 13 feet of fill material were found across the site. The presence of fill in all eight on-site soil borings suggests that the entire site has been reworked to some degree in conjunction with activities associated with the disposal pit.
- Waste materials consisting of multi-colored sludges, solids, and oily refuse were found underlying the fill over a major portion of Site H. The maximum thickness of waste encountered was 20 feet, in the central section of the site.
- Wastes at Site H were found directly overlying Cahokia or Henry Formation sands, which were found stained, below the disposal pit. Waste materials are below the water table, which averages 10 feet below ground surface.

Site I/CS-A

- Two disposal pits were identified at Site I. The larger of the two, located south of the access road from the Cerro plant (old Queeny Avenue), was part of a larger pit, the remainder of which is the pit in Site H. The smaller pit is located north of the access road.
- Fill material was found covering most of Site I. Fill ranged in thickness from 3 feet - outside the disposal pit areas - to 13 feet covering both disposal pits.

- Waste materials found below the fill at Site I consisted of oily sand, clay, wood, and cinders, mixed with occasional refuse such as cardboard, rubber, and cloth. Sludge-like material was also found in both pits. The depth of both pits is at least 23 to 25 feet.
- Both pits appear to terminate in fine sand and sandy silt deposits characteristic of the lower portion of the Cahokia Alluvium. These materials were found stained below both pits. Waste materials within the two pits are below the water table, which averages 10 feet below ground surface.
- Sediment samples from both the northern and southern segments of CS-A consisted predominantly of sandy silt, suggesting that the creek bottom may be heavily silted along its entire length.

Site L

- Data from soil borings indicates that the surface impoundment at Site L was a shallow excavation, approximately 8 feet deep, and dug into the sandy silt deposits of the upper Cahokia Alluvium. This impoundment at Site L has been filled with cinders, clay, concrete, and brick. Staining of the sandy silt deposits observed in the unsaturated zone indicates that these materials are permeable enough to have allowed contaminant migration to the saturated zone.

Creek Sector B

- The creek bed in CS-B consists of fine-grained silt and clay that have filled the old flow channel of the creek. Erosion and slumpage of clay and silt from the steep banks of the creek have also contributed to the siltation of the creek bed.
- Rubbery wastes from the former Midwest Rubber Company outfall were found at the surface of the creek bed in the northern half of CS-B.

- The culvert connecting CS-B to CS-A to the north has been blocked, prohibiting flow between the two creek sectors. The culvert at the south end of CS-B has also been partially blocked, causing creek water to pond and sediment to accumulate in the southern half of CS-B, north of Judith Lane.

Peripheral Sites

Site J

- At Site J, the area behind the Sterling Steel Plant appears to have been used for the disposal of spent foundry sand, slag, and construction debris. Four to six feet of this material was found overlying upper Cahokia silty clay and sandy silt in this area.
- Data from boring J3, drilled approximately 15 feet south of the open pit southeast of the foundry, showed 18 feet of fill, including foundry sand, overlying medium-grained sand. This suggests that the present pit was once larger in diameter and has since been partially filled.
- Although organic contamination of subsurface soils was detected at Site J, no visibly contaminated soils were observed in any of the borings at the site.
- Groundwater was encountered at 12 to 14 feet below the surface in each boring.

Site K

- At Site K, 10 to 15 feet of fill consisting of a mixture of brown silty clay, sand, and rock or brick fragments, overlying discontinuous layers of fine to coarse sand and silty clay were found in soil borings.
- Although waste materials were not observed in any of the three borings drilled at the site, black-stained soils were observed

in each boring near the bottom of or immediately below the fill material.

- Groundwater was encountered at 7 to 10 feet below the surface in each boring.

Site N

- Site N is a road construction material borrow pit that has been partially filled with concrete, rubber, and other demolition debris. Three to ten feet of this fill material was found overlying interbedded silty sand, sandy silt, and fine sand typical of the Cahokia Alluvium.
- No waste materials were found in either of the two borings drilled at the site. However, black and reddish-brown staining was noted on silt and sand samples from 6 to 10 feet in boring N1.
- Groundwater was encountered at approximately 1 foot below the surface, due to the location of the borings at a relatively low elevation within the partially filled pit.

Site P

- Data from soil borings indicate that fill material consisting of silty clay, cinders, slag, and refuse has been disposed directly onto the land surface. The thickness of fill ranges from 13 to 28 feet.
- With the exception of boring P1, fine- to medium-grained sand was found immediately below the fill at each boring location. In P1, 5 feet of clay separated the fill material from underlying sand deposits.
- Significant waste material layers were not observed at any of the boring locations. However, analysis of a composite

subsurface soil sample (sample DC-P1-53) indicates that fill material may be contaminated.

- Groundwater levels in borings were generally 25 to 30 feet below the surface in the sand deposits below the fill.

Area 2

Site 0

- The four inactive sludge dewatering lagoons which compose Site 0 were found to be covered with a silty clay cap which ranged in thickness from 1 to 7 feet in borings across the site.
- Results from soil borings indicate that much of the sludge material was probably removed prior to capping. However, some sludge or sludge neutralized with lime was found in three of the five borings drilled in the closed lagoons. The thickness of this material ranged from 0.5 feet in boring 03, to 2 feet in boring 010. Staining was also observed in the sand deposits immediately below this material.
- In areas outside of the lagoons, the general stratigraphy consists of 2 feet of fill overlying 13 feet of discontinuous silt, clay, and silty sand layers, which gradually grade into a clean (silt-free) fine- to medium-grained sand at 15 to 20 feet below the surface.
- Groundwater levels averaged 14.5 feet below the surface at Site 0.

Site Q

- Data from soil borings in the northern half of Site Q indicate that the site is covered with approximately 4 feet of permeable cinders and fly ash used as a cover material for the refuse and fill buried below.

- The refuse and fill consists of a mixture of municipal garbage, clay, cinders, and construction debris, which is frequently oily and black from staining. The thickness of this material was found to range from 3 to 17 feet (E & E 1983).
- Below the fill are silt and silty sands of the Cahokia Alluvium. These deposits coarsen with depth and eventually grade into lower Cahokia/upper Henry formation sands at approximately 43 feet.
- In the southern half of Site Q, a similar mixture of fill material was found to depths of 16 to 28 feet; however, oils and general staining were not observed.
- Boring results in the southern half of the site indicate that Cahokia materials (clays and silts) may have been excavated prior to disposal of refuse at boring locations Q4 and Q5.
- The water table was encountered in the silty sand deposits below the fill at an average depth of 27 feet.

Site R

- Geologic and soils data for Site R were derived from previous reports developed by D'Appolonia (1980), and Geraghty & Miller (1986). In general, borings through Site R indicate that below a 3- to 6-foot clay cap is 5 to 20 feet of fill consisting of fly ash, cinders, clay, sand, miscellaneous debris (e.g., glass, metal) and unidentified waste.
- Below the fill is 15 to 20 feet of Cahokia Alluvium which grades to a fine- to medium-grained clean sand that coarsens with depth. Deeper borings indicate that sand continues to bedrock with cobble and boulder layers encountered at 68 to 126 feet.
- Groundwater occurs in the alluvium below the fill and fluctuates in depth in response to changing Mississippi River levels.

Perched conditions exist at some locations around the site following periods of high river stage.

7.2.5 Groundwater Hydrology

- Groundwater exists in both the Cahokia Alluvium and Henry Formation valley fill materials under water table and leaky artesian conditions.
- Cahokia and Henry formation strata have been classified as a single hydrogeologic unit due to the hydrologic connectivity exhibited between strata and the lack of significant confining layers between or within the individual strata.
- To facilitate the hydrogeologic evaluation of the area, this unit has been divided into three zones based on their relative hydraulic conductivities. These zones are: shallow zone - a relatively lower conductivity zone composed of the alluvial silty sand and fine-grained sand deposits found below the surficial silts and clays. It extends from the water table to a depth of approximately 45 feet below the surface. Intermediate zone - this zone includes the medium to coarse valley train sand and gravel of the Henry Formation from 45 to 75 feet below the surface. It is approximately 20 to 30 times more permeable than the shallow zone. Deep zone - this zone includes the coarsest, most permeable deposits of the Henry Formation which directly overlie the bedrock. It extends from 75 feet to approximately 120 to 130 feet below the surface.

Historical Groundwater Flow

- The DCP area has historically been one of the major centers for groundwater withdrawals in the American Bottoms.
- From the 1940s until approximately 1980, heavy pumping from the intermediate and deep zones of the valley fill deposits at the Monsanto Chemical Corporation and surrounding industry wells

produced a deep cone of depression which lowered the water table and diverted the natural groundwater flow direction (east to west toward the Mississippi River) to radial flow from all directions toward the pumping centers.

- During this period, groundwater withdrawals also established hydraulic gradients from the river toward pumping locations producing the diversion of river water into the aquifer by the process of induced infiltration.
- The effect of this pumpage in the DCP area would have been to draw leachate and contaminants from the shallow zone at Area 1 and Area 2 sites off-site toward the pumping locations and into the more permeable intermediate zone, and possibly the deep zone. Once in these deeper zones, due to the more permeable conditions in the deeper zones, it is likely that contaminants migrated farther and faster than if they had remained in the lower-permeability shallow zone.
- Pumping effects on contaminant migration continued until approximately 1980, when significant industrial well withdrawals were halted. At this time, flow patterns to the Mississippi River were resumed, and the potential for contaminant discharge to the river was established.

Current Groundwater Flow

Area 1

- Groundwater flow direction in the shallow zone was found to be west to slightly northwest, toward the Mississippi River, on all three water level measurement dates.
- The average horizontal gradient was calculated to be 0.00077. The average hydraulic conductivity value, calculated using slug test data from eight Area 1 wells screened in the shallow zone, is 1.2×10^{-4} ft/sec. Using these values and assuming an ef-

fective porosity of 0.15, the average groundwater velocity was calculated to be 0.0053 ft/day (19.4 ft/yr).

- Based on water level measurements at Site I, water in CS-A appears to be the result of storm runoff and drainage from the Cerro plant. This water is perched, due to the heavily silted creek bed above the water table.
- Water levels in wells adjacent to the northern half of CS-B were consistently below the creek bed elevation, indicating that CS-B is not a significant discharge or recharge point for local groundwater flow. However, groundwater, even during periods of low levels, is in contact with contaminated creek sediments which extend to a depth of approximately 7 feet below the creek bed.

Area 2

- Due to the proximity of Area 2 sites to the river and the hydraulic connection between the groundwater system and the river, groundwater flow directions, gradients and velocities are affected by fluctuations in the Mississippi River stage.
- During periods of low river stage, groundwater flow direction is in a west-northwest direction, toward the river. This pattern was observed at Site O on all three measurement dates and at Site Q on two of the measurement dates.
- At Site O, using the average hydraulic conductivity (K) value of 2.0×10^{-4} ft/sec (calculated using data from seven Area 2 slug tests), the average gradient (i) of 0.0008, and assuming an effective porosity (ne) of 0.15, the average flow velocity toward the river in the shallow zone was 0.0968 ft/day (35.3 ft/yr).
- At Site Q, for the two dates that flow was toward the river, the average flow velocity was 0.2938 ft/day, using $K = 2.0 \times 10^{-4}$ ft/sec, $i = 0.003$, and $ne = 0.15$.

- When river levels exceed groundwater elevations, a hydraulic gradient from the river is produced, reversing groundwater flow direction away from the river. This flow pattern was observed at Site Q on the March 26 measurement date. Flow velocity at Site Q was calculated to be 0.0382 ft/day away from the river on this date.
- The eastward extent of flow reversal in the study area (delineated by the location of a groundwater divide) is dependent on the stage at which the Mississippi River crests. Flow reversals also occur in the deeper zones of the aquifer.

7.2.6 Infiltration Tests

- Results of infiltration tests indicate that the heterogeneous fill materials found at the DCP sites exhibit a wide range of infiltration rates. Because of the absence of surface soil uniformity at the DCP sites, infiltration rates within areas of each site may vary significantly.

7.2.7 Chemical Results

7.2.7.1 Soil Gas Monitoring

Area 1

- Eleven locations tested for volatile soil gases at Site G provided only limited indication of the presence of subsurface volatile organics. Only two locations (SG-11 and SG-12) measured greater than 100 mg/L.
- Soil gas analysis at Site H showed six of the twelve locations tested had concentrations of volatile organic soil gases greater than 1,000 mg/L. The high concentrations trended toward the northern portion of the site, near the center of the excavation seen in historical aerial photographs.

- Six of the nineteen locations tested for volatile organic soil gases at Site I and CS-A showed concentrations of volatile organics in excess of 1,000 mg/L. High concentrations were centered around the south perimeter, near the center of the excavation that is contiguous with Site H, and near the west perimeter, which is downgradient, or at, the west edge of the excavation.
- Soil gas results for Site L identified three locations, of ten locations tested, where volatile organics were detected at greater than 1,000 mg/L. Two additional locations had concentrations substantially above background. Based on measurements from historical aerial photographs, all of these locations fall within the area of the former surface impoundment.
- Soil gas analysis at seven locations in CS-B identified two locations where concentrations of volatile organic soil gases were substantially above background conditions. These included SG-28 and SG-46, which had concentrations of greater than 100 mg/L and 280 mg/L, respectively. Both locations were in the northern 300 feet of the creek sector, near areas reported to have received discharges from area industries.

Peripheral Sites

- Soil gas results for Site J identified four locations where volatile organic soil gases were detected at concentrations substantially above background. Two tests (SG-79 and SG-88) indicated concentrations greater than 1,000 mg/L.
- Of the eight locations tested for volatile organic soil gases at Site K, four showed concentrations substantially above background. Three of these locations, all near the western perimeter of the former excavation, had concentrations of volatile organics in excess of 1,000 mg/L.

- Six locations tested for volatile organic soil gases along the banks of Site M provided only limited indications of the presence of volatile compounds. Two locations, near the north central portion of the site and near the northeast corner, showed concentrations of 18 mg/L and 16 mg/L, respectively.
- Soil gas analysis at Site N showed five of the eight locations tested had concentrations of volatile organic soil gases substantially above background concentrations. Two of these locations had concentrations greater than 1,000 mg/L. The high concentrations trended from the central portion of the excavated area toward the southeast corner.
- Three locations tested for volatile organic soil gases in CS-C provided only limited indications of the presence of volatile contaminants. The highest detected concentration was 1.5 mg/L at SG-26, located approximately 200 feet south of Judith Lane.

7.2.7.2 Surface Water and Sediments

- Analytical results of the surface water and sediment sampling revealed contamination in all four creek sectors sampled (A, B, C, and D), and in the pond which constitutes Site M.
- Volatile organic contaminants were detected in two of eleven surface water field samples. Both samples in which volatiles were detected were collected from CS-A. Eight volatile compounds were detected, with the highest concentration being 0.041 mg/L of 1,1,1-trichloroethane.
- Semivolatile organic contaminants were detected in two of the eleven surface water field samples. Two semivolatiles were detected, with the high concentration being 0.009 mg/L of 2-nitroaniline in CS-B. One sample collected from CS-A contained 4-chloroaniline at 0.003 mg/L.

- Aroclor 1260 was detected in three of the eleven surface water field samples. All three samples were collected from CS-B, and the highest concentration detected was 0.044 mg/L in a sample from near the south end of CS-B. No other pesticides or PCBs were detected in the surface water samples.
- Elevated concentrations of several heavy metals were detected in surface water samples collected from each creek sector. Cadmium, mercury, copper, barium, arsenic, chromium, and lead were all detected at relatively high concentrations, with the highest detected concentration being 17,900 mg/L of copper in a sample from CS-B.
- Due to the physical characteristics of Dead Creek, the collection of an upstream, or background, sample was not possible. The creek effectively begins at CS-A, which along with CS-B, is the most heavily contaminated portion of the creek.
- Due to the blocked culverts at Queeny Avenue and Judith Lane, CS-A and CS-B are effectively surface impoundments. Both CS-A and CS-B collect surface runoff and rainwater, and surface water contamination in these sectors is likely the result of mixing with sediments.
- Volatile organic contaminants were detected in two of the 21 sediment samples. Six volatiles were detected in one sample collected from the northern portion of CS-B, with the highest detected concentration being 5.2 mg/kg of chlorobenzene.
- Analysis of the 21 sediment samples revealed the presence of semivolatile organic contaminants in all samples. A total of 29 different semivolatiles was detected, with the highest concentration detected being 220 mg/kg of 1,4-dichlorobenzene in a sample from CS-B. Benzo(a)pyrene was the most frequently detected semivolatile, being detected in 13 of the 21 sediment samples.

- PCBs were detected in 18 of the 21 sediment samples. The highest PCB concentration detected was 480 mg/kg of Aroclor 1248 in a sample from CS-B. Aroclors 1254 and 1260 were each detected in 14 samples. Endrin was detected in one sample, from CS-D, at a concentration of 0.58 mg/kg.
- Analysis of seven sediment samples from six locations in CS-B, CS-C, and CS-D showed no detectable concentration of 2,3,7,8-TCDD.
- Analysis of the 21 sediment samples revealed elevated concentrations of cadmium, mercury, copper, barium, arsenic, chromium, and lead. With the exception of cadmium, the highest concentrations were detected in CS-A and CS-B. The highest concentration was 17,300 mg/kg of barium in a sample from CS-B.
- Analysis of subsurface sediment samples revealed contamination in all creek sectors. The subsurface sediment samples were collected at depths ranging from 1.5 feet to 3 feet.
- The highest total organic concentration in sediment was 870 mg/kg in a sample from CS-B. This concentration included 480 mg/kg of Aroclor 1248. The sediment sample was collected from a depth of 2 feet to 3 feet.
- The highest concentrations of organic contaminants were detected in sediment samples from CS-A and CS-B. This is consistent with the fact that flow is restricted in each of these sectors, leading to increased deposition of contaminants bound to sediments.
- Two old effluent pipe outlets are located in the northern 300 feet of CS-B. Staining is evident around each pipe, and a large area of the creek bed is covered with a rubbery material in the vicinity of the outlet pipe on the west bank of the creek. This physical evidence, along with the high concentrations of organic

contaminants detected in samples from this area, substantiates reports of past discharge of chemical wastes directly to the creek.

7.2.7.3 Surface Soils

- Analysis of surface soil samples from Site G indicated surficial contamination across the entire site. Of the 43 samples submitted for analysis, only one sample showed no detected concentrations of organic contaminants. The remaining samples contained total organic concentrations ranging from 0.2 mg/kg to over 74,000 mg/kg. All surface soil samples were collected from the surface to a depth of 6 inches.
- Twelve volatile organic compounds were detected in surface soil samples from Site G. The most frequently detected volatile contaminant was 4-methyl-2-pentanone, which was detected in 22 samples. Other volatile organic contaminants detected in more than one sample included toluene, tetrachloroethene, benzene, ethylbenzene, and xylene.
- Semivolatile organics were detected in 33 of the 43 surface soil samples from Site G. The highest concentrations of semivolatiles included 22,000 mg/kg of 1,4-dichlorobenzene and 21,000 mg/kg of pentachlorophenol. Pentachlorophenol was detected in 14 samples, benzo(a)pyrene was detected in 13 samples, and pyrene was detected in 12 samples. The highest concentration of benzo(a)pyrene was 22 mg/kg.
- Analysis of the 43 surface soil samples from Site G revealed the presence of PCBs in 40 samples, and the pesticide degradation product 4,4'-DDE in five samples. Three PCB congeners were detected in the samples, including Aroclor 1248, Aroclor 1254, and Aroclor 1260. Six surface soil samples contained PCB concentrations greater than 1,000 mg/kg. The highest PCB concentrations were found in sample SS-11, which contained 24,000 mg/kg of Aro-

clor 1248, 29,000 mg/kg of Aroclor 1254, and 21,000 mg/kg of Aroclor 1260. Of the five samples in which 4,4'-DDE was detected, sample SS-07 contained the highest concentration at 0.29 mg/kg. Octachlorodibenzo(b,e)dioxin (OCDD) was detected in three samples, with a maximum concentration of 130 mg/kg detected in sample SS-25.

- No 2,3,7,8-TCDD was detected in two composite surface soil samples from Site G which were analyzed specifically for this compound.
- Analysis of the 43 surface soil samples from Site G revealed elevated levels of antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, vanadium, zinc, and cyanide. Cyanide was detected in 18 samples, with a high concentration of 22 mg/kg. Mercury was detected in 38 samples, with a high concentration of 23 mg/kg.
- The surficial contamination at Site G is spread across the entire site. High concentrations of organics were detected in samples from the southern perimeter of the site, along a ridge where many corroded drums were observed on the surface, and near the northeast corner of the site, in the vicinity of two oily pits.
- As a result of the high levels of organic contamination found on the surface at Site G, Monsanto constructed a chain-link fence around the site in order to restrict access to the general public. The construction was done under the oversight of USEPA.
- No organic contaminants were detected in surface soil samples from Site J. Elevated levels of chromium, iron, manganese, and nickel were detected. These results indicate that the casting sand, slag, and construction debris seen on the surface of the site were the only materials disposed of on the surface at Site J.

7.2.7.4 Subsurface Soils

- Organic contaminants were detected in subsurface soils at all sites sampled. The highest concentrations were detected in samples from Sites G, H, I, and O. Previous investigations also indicated similar levels of subsurface contamination at Sites Q and R. In summary, all Area 1 and Area 2 sites contain significant concentrations of a variety of organic contaminants in subsurface soils.

Area 1

- Analysis of the 12 subsurface soil samples from nine borings at Site G revealed the presence of organic and inorganic contaminants in 11 samples. These results show subsurface contamination across the entire site to a depth of at least 20 feet. Waste material was seen in borings G5, G6, G7, G8, and G9 at depths ranging from approximately 5 feet to 35 feet. Analysis of three samples collected from the waste material showed high levels of organic contaminants. The most frequently detected organics were chlorobenzene (9 samples), tetrachloroethene (8 samples), benzene (7 samples), naphthalene (7 samples), and Aroclor 1260 (6 samples).
- Total organic concentrations in subsurface soils ranged from 0 in the background boring G1 to 10,000 mg/kg in boring G8, located in the east-central portion of the site. The highest concentrations of contaminants detected were 540 mg/kg of chlorobenzene, 5,400 mg/kg of naphthalene, 4,800 mg/kg of pentachlorophenol, and 4,400 mg/kg of Aroclor 1260. A total organic concentration of 970 mg/kg was detected in a sample from a depth of 35 to 40 feet. This sample consisted of visibly stained sand below waste material. A sample collected at a depth of 20 to 30 feet also consisted of stained sand below waste material. This sample had a total organic concentration of 1,500 mg/kg. The most highly contaminated samples had total organic concentrations of 10,000 mg/kg and 2,400 mg/kg. Both of these samples

consisted of waste material and soil from a depth of 10 to 25 feet.

- Analysis of the 11 subsurface soil samples from nine borings at Site H revealed the presence of organic contaminants in nine samples. The results showed high concentrations of organic contaminants centered in the north and central portions of the site. These results are consistent with the location of the excavated area identified in historical aerial photographs. Contamination was detected at a maximum depth of 35 to 50 feet at the site. Contaminants detected in the sample from this depth included chlorobenzene, 2,4-dichlorophenol, 1,2,4-trichlorobenzene, hexachlorobenzene, and Aroclor 1260. The most frequently detected organics were benzene (7 samples), Aroclor 1260 (7 samples), chlorobenzene (6 samples), 1,2,4-trichlorobenzene (6 samples), and phenanthrene (6 samples).

- Total organic concentrations in subsurface soils ranged from 0 in the background boring H9 to 60,000 mg/kg in boring H1. The highest concentrations of contaminants detected were 31,000 mg/kg of 1,4-dichlorobenzene in boring H-1, 19,000 mg/kg of 1,2-dichlorobenzene in boring H1, 18,000 mg/kg of Aroclor 1260 in boring H4, and 2,100 mg/kg of phenanthrene in boring H2. Sample H1-14 consisted of waste material at a depth of 15 to 25 feet. Two additional samples consisting of waste material from similar depths, H2-16 and H4-19, contained total organic concentrations of 12,000 mg/kg and 20,000 mg/kg, respectively. Samples collected from sand below the waste material in two borings, H1 and H6, contained total organic concentrations of 8 mg/kg and 2 mg/kg, respectively.

- Analysis of the 16 subsurface soil samples from 10 borings at Site I revealed the presence of organic contaminants in 12 samples. The results showed high concentrations of organic contaminants across most of the site to a depth of at least 25 feet. Samples collected from within the excavated areas

*how was H9
selected as background?*

identified in historical aerial photographs all showed high levels of contamination. The same contaminants found in subsurface soils at Sites G and H were also consistently detected in the subsurface soils at Site I. Contamination was detected at a maximum depth of 38 feet in borings I5 and I9. The most frequently detected contaminants were chlorobenzene (12 samples), toluene (11 samples), ethylbenzene (10 samples), naphthalene (7 samples), and Aroclor 1260 (5 samples).

- Total organic concentrations in subsurface soils at Site I ranged from 0 in the background boring I12 to 11,000 mg/kg in boring I5. The highest concentrations of contaminants detected were 8,300 mg/kg of 1,2,4-trichlorobenzene, 1,300 mg/kg of hexachlorobenzene and 340 mg/kg of Aroclor 1260 in boring I5, 1,800 mg/kg of 1,4-dichlorobenzene in boring I11, and 490 mg/kg of toxaphene in boring I6. A total organic concentration of 11,000 mg/kg was detected in sample I5-41, which was composited from waste material and soil at a depth of 5 to 27.5 feet. Five additional samples contained waste material at similar depths, with the highest detected concentrations of total organics being 2,500 mg/kg in sample I2-39 and 2,200 mg/kg in sample I11-51. Samples collected from sand below the waste material in borings I5, I10, and I11 contained total organic concentrations of 960 mg/kg, 273 mg/kg, and 160 mg/kg, respectively.
- Analysis of the five subsurface soil samples from four borings at Site L revealed the presence of organic contaminants in four samples. The most frequently detected contaminants were toluene (4 samples), benzene (4 samples), 4-methyl-2-pentanone (4 samples), phenol (2 samples), and pentachlorophenol (2 samples). No pesticides or PCBs were detected in the samples from Site L.
- Total organic concentrations in subsurface soils at Site L ranged from 0.008 mg/kg in upgradient boring L1 to 120 mg/kg in boring L3. The highest concentrations of contaminants detected were 58 mg/kg of pentachlorophenol, 27 mg/kg of toluene, 20

mg/kg of trans-1,2-dichloroethene, and 4.2 mg/kg of benzene. A total organic concentration of 120 mg/kg was detected in sample L3-04, which was composited from fill and silt at a depth of 5 to 15 feet. The analytical results indicate that samples L2-03 and L3-04 were collected within the area of the former surface impoundment, while samples from borings L1 and L4 were outside the boundaries of the impoundment.

- In summary, the analytical results of the subsurface soil sampling at the Area 1 sites showed the presence of common waste types at each of the sites. Toluene, benzene, chlorophenols, and PAHs were detected at each of the sites. With the exception of Site L, PCBs were also detected in the subsurface soils at each site. Organic contaminants were found to a depth of at least 20 feet at all Area 1 sites.

Area 2

- Previous investigations and sampling have indicated significant organic contamination in subsurface soils at Sites Q and R. Only limited data were available for subsurface conditions at Site O. For this reason, Site O was the only Area 2 site at which subsurface soil samples were collected.
- Analysis of the 11 subsurface soil samples from eight borings at Site O detected the presence of organic contaminants in nine samples. The data showed subsurface contamination across the entire site, with the highest concentrations found in samples from the northern portion of former lagoons 2 and 3. The maximum depth at which contamination was detected was 30 feet in boring O2, located along the west (downgradient) perimeter of the site. The most frequently detected organics were xylene (9 samples), ethylbenzene (9 samples), chlorobenzene (8 samples), pentachlorophenol (6 samples), chrysene (6 samples), and Aroclor 1242 (5 samples).

- Total organic concentrations in subsurface soils at Site O ranged from 0 in the background boring 01 to 5,000 mg/kg in boring 010. The highest concentrations of contaminant detected were 1,900 mg/kg of Aroclor 1242, 620 mg/kg of xylene, 470 mg/kg of pentachlorophenol, and 110 mg/kg of 1,4-dichlorobenzene. The two most highly contaminated subsurface soil samples at Site O were 04-62 and 010-74. Both of these samples consisted of sand and sludge composited from a depth of 5 to 10 feet. Sand below the waste material was sampled in borings 03, 05, 09, and 010. These samples contained total organic concentrations of 29 mg/kg, 37 mg/kg, 35 mg/kg, and 92 mg/kg, respectively.

Peripheral Sites

- Analysis of the three subsurface soil samples from three borings at Site J revealed the presence of organic contaminants in two samples. Ethylbenzene, xylene, 1,4-dichlorobenzene, dibenzofuran, phenanthrene, and Aroclor 1260 were each detected in one sample. The highest total organic concentration detected in subsurface soils at Site J was 110 mg/kg in boring J2, located near the southeast corner of the surface disposal area. This sample was composited from a depth of 15 to 25 feet. Boring J1, located near the center of the surface disposal area, showed no detected concentrations of organic contaminants.
- Analysis of three subsurface soil samples from three borings at Site K revealed the presence of organic contaminants in all three samples. Organics detected included toluene (1 sample), phenanthrene (3 samples), pyrene (3 samples), benzo(a)pyrene (3 samples), and PCBs (3 samples). The highest concentration detected was 120 mg/kg of Aroclor 1248 in sample K1-08. Total organic concentrations in subsurface soils at Site K ranged from 23 mg/kg in borings K2 and K3 to 150 mg/kg in boring K1. Samples from borings K1 and K2 were composited from depths of 0 to 10 feet. Sample K3-32 was composited from a depth of 10 to

20 feet. The analytical results show contamination across the entire site to a maximum depth of 20 feet.

- Analysis of the two subsurface soil samples from two borings at Site N revealed the presence of organic contaminants in both samples. The contaminants detected consisted mainly of PAHs, including phenanthrene, fluoranthene, pyrene, and benzo(a)-pyrene. No pesticides or PCBs were detected. The highest concentration detected was 0.68 mg/kg of fluoranthene. A total organic concentration of 3.6 mg/kg was detected in sample N1-05. The sample was composited from the surface to a depth of 10 feet.
- Analysis of four subsurface soil samples at Site P revealed the presence of organic contaminants in two samples. Contaminants detected included ethylbenzene, toluene, chlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, and phenol. The highest concentrations of contaminants detected were 8.9 mg/kg of 1,4-dichlorobenzene in sample P1-53, and 3.9 mg/kg of phenol, also in P1-53. A total organic concentration of 18 mg/kg was detected in sample P1-53, which was composited across four borings in the northern two-thirds of the site at a depth of 0 to 10 feet. Sample P2-54 was composited across the same four borings at a depth of 25 to 35 feet, and contained a total organic concentration of 0.03 mg/kg. No organics were detected in boring P5, located near the southwest corner of the site.

7.2.7.5 Groundwater

- Organic contaminants were detected in groundwater samples from each of the sites sampled. The same contaminant types were consistently detected across all of the Area 1 and Area 2 sites. Since the groundwater sampling was limited to monitoring a relatively shallow portion of the aquifer, a true representation of the extent of groundwater contamination cannot be provided based on this data.

Area 1

- Analysis of the nine groundwater samples from eight monitoring wells located on or around Site G revealed organic contaminants in all nine samples. The most frequently detected contaminants were chlorobenzene (7 samples), naphthalene (5 samples), toluene (4 samples), benzene (4 samples), 2-chlorophenol (4 samples), and Aroclor 1260 (3 samples). Total organic concentrations in groundwater samples from around Site G ranged from 0.02 mg/L to 258 mg/L. The highest concentrations of contaminants detected were 150 mg/L of benzoic acid, 21 mg/L of naphthalene, 15 mg/L of 4-chloroaniline, and 30 mg/L of phenol. The highest total organic concentration in groundwater samples from around Site G was 258 mg/L, from a well screened in sand below waste materials at the site. Downgradient wells EE-G101 and EE-05 at Site G showed only limited organic contamination. This is probably due to a combination of factors, including past groundwater pumpage, the presence of a vertical component of groundwater flow in the area, and the relatively shallow depth of the wells.
- Analysis of the five groundwater samples from five monitoring wells on or around Site H revealed organic contaminants in the four samples on the site. No organic contaminants were detected in the background well EE-04. The most frequently detected organics were chlorobenzene (4 samples), benzene (4 samples), 4-chloroaniline (4 samples), and 1,4-dichlorobenzene (3 samples). Total organic concentrations in groundwater samples from Site H ranged from 0 in well EE-04 to 44 mg/L in well EE-02. The highest detected concentrations of contaminants were 7.3 mg/L of toluene, 6.4 mg/L of 4-chloroaniline, 11 mg/L of chlorobenzene, and 5.8 mg/L of benzoic acid. The highest total organic concentrations in groundwater samples from Site H were 44 mg/L and 17 mg/L in wells EE-02 and EE-01, respectively. Well EE-02, located adjacent to the west perimeter of the site, was finished in sand with the screened interval from 384.66 above MSL to 389.66 above MSL. Well EE-01, located in the northwest corner of the site within the excavated area

identified in historical aerial photographs, was finished in sand below waste material with the screened interval being between 373.55 MSL and 378.55 MSL. Well EE-G110, located adjacent to Dead Creek to the west of Site H, contained lower concentrations of the same contaminants found in wells EE-01 and EE-02. The results in well EE-G110 are probably indicative of horizontal flow in the shallow zone. Many of the contaminants found in wells EE-01 and EE-02 are expected to follow a vertical flow path to the intermediate zone, which would carry the contaminants below the screened interval at well EE-G110.

- Analysis of the eight groundwater samples from seven monitoring wells at Site I revealed the presence of organic contaminants in six samples. The most frequently detected contaminants were chlorobenzene (6 samples), benzene (6 samples), 4-chloroaniline (6 samples), 1,4-dichlorobenzene (5 samples), and pentachlorophenol (4 samples). Total organic concentrations in groundwater samples from Site I ranged from 0 in the background well EE-20 to 28 mg/L in well EE-14. The highest concentrations of contaminants detected were 9.6 mg/L of 4-chloroaniline, 3.1 mg/L of chlorobenzene, and 2.4 mg/L of pentachlorophenol. The two wells which exhibited the highest total organic concentrations were EE-14 and EE-16, with concentrations of 28 mg/L and 14 mg/L, respectively. Well EE-14 is located within the area of the north excavation at Site I identified in historical aerial photographs, and is screened in sand below waste material. Well EE-16 is located immediately west of the south excavation, and is screened in sand. No waste material was evident in the boring at this location. Downgradient wells at Site I contained lower concentrations of the same contaminants found in wells EE-14 and EE-16, indicating migration of contaminants from the two former excavations at the site.
- A total organic concentration of 2.6 mg/L was detected in the one downgradient groundwater sample at Site L. The background well EE-G108 contained a total organic concentration of 0.002

mg/L. Contaminants detected in the downgradient sample included toluene, chloroform, phenol, 2-chlorophenol, and 4-chloroaniline, with the highest concentration detected being 0.97 mg/L of toluene. The same contaminants found in subsurface soils at Site L were also found in the downgradient groundwater sample, indicating that contaminants have migrated from the area of the former surface impoundment.

Area 2

- Analysis of five groundwater samples from five monitoring wells at Site O revealed the presence of organic contaminants in three samples. Significant contamination was found in only one sample, GW-39A, which contained 16 volatiles and 11 semivolatile organic contaminants. A total organic concentration of 490 mg/L was detected in sample GW-39A. Contaminants detected included chlorobenzene at 180 mg/L, benzene at 150 mg/L, trichloroethene at 64 mg/L, 1,4-dichlorobenzene at 15 mg/L, and phenol at 1.1 mg/L. This sample location was immediately west of the former sludge lagoons, and the well was screened between 28 and 33 feet deep. An active pumping well at Clayton Chemical Company is located approximately 150 feet to the northwest of this location. The chemical results indicate that the pumping well has a direct influence on the migration path of contaminants from Site O by forming a slight cone of influence in the immediate area around the well. The presence of this pumping well may also explain the lack of contamination in downgradient well EE-25. The background sample for Site O contained no detected organic contaminants. This sample was collected from well EE-21, located to the northwest of the former lagoons.
- Analysis of the nine groundwater samples from eight monitoring wells at Site Q revealed the presence of organic contaminants in all nine samples. The results show contamination across the entire site, although the most significant contamination was limited to the northern portion of the site, adjacent to Site R. Considering the fact that the groundwater gradient is reversed

during periods of high river stage elevations, the chemical results indicate that both Site Q and Site R have influenced groundwater quality in wells EE-18 and EE-19. The background well for Sites Q and R, well EE-17, contained a total organic concentration of 0.04 mg/L, which included 0.03 mg/L of chlorobenzene. This well is located to the northeast of Sites Q and R, but is also downgradient from several industrial properties which may contribute to the contaminants found in the well. Total organic concentrations of 330 mg/L and 50 mg/L were detected in samples from wells along the west perimeter of the northern portion of Site Q, and adjacent to Site R. Contaminants detected in these wells included chlorobenzene at 6.7 mg/L, phenol at 190 mg/L, pentachlorophenol at 35 mg/L, and 4-chloroaniline at 15 mg/L. Groundwater from monitoring wells in the southern portion of Site Q showed only limited organic contamination. Total organic concentrations of 0.15 mg/L, 0.28 mg/L, 0.01 mg/L, 0.03 mg/L, and 0.40 mg/L were detected in these wells. Contaminants detected in these wells included benzene, chlorobenzene, xylene, and 4-chloroaniline.

- Analysis of the seven groundwater samples from six monitoring wells at Site R revealed the presence of organic contaminants in all seven samples. Based on the results, groundwater contamination at Site R was more significant in the northern one-half of the site than in the southern portion. Wells P-7 and P-11, located adjacent to the river west of the northern portion of Site R, both contained higher concentrations of contaminants than wells B-26A, B-28A, and P-1, to the south. The most frequently detected contaminants at Site R were chlorobenzene (7 samples), 2-chlorophenol (6 samples), benzene (5 samples), toluene (4 samples), 4-chloroaniline (4 samples), and 1,4-dichlorobenzene (4 samples). Total organic concentrations in groundwater samples from Site R ranged from 0.04 mg/L to 130 mg/L. The sample containing 130 mg/L was collected from well B-25A at the east side of the site. The sample consisted of an oily, reddish colored liquid, indicating that the well is

screened in waste material. Sample GW-46, collected from well P-7 adjacent to the Mississippi River contained the highest downgradient total organic concentration (70 mg/kg). The highest concentrations of contaminants detected were 60 mg/L of phenol, 25 mg/L of 4-chloroaniline, 16 mg/L of 1,2-dichloroethane, and 14 mg/L of 2-chlorophenol.

Private Wells

- Analysis of groundwater samples from four residential wells on Judith Lane to the south of the Area 1 sites revealed the presence of low-level organic contamination in three wells. Contaminants detected in these samples included toluene, ethylbenzene, carbon disulfide, and styrene. No semivolatiles, PCBs, or pesticides were detected in the residential well samples.
- Analysis of the groundwater sample from the Clayton Chemical Company well, approximately 150 to 200 feet west of Site 0, revealed the presence of eight volatile and two semivolatile organic contaminants. A total organic concentration of 0.27 mg/L was detected in the groundwater sample from the Clayton Chemical Company well. Contaminants detected included many of the same contaminants found in groundwater and subsurface soil samples from Site 0, such as toluene, benzene, chlorobenzene, and 1,4-dichlorobenzene. The Clayton well is approximately 70 feet deep, and an average of approximately 1,000,000 gpm are pumped from the well for process use at Clayton.

7.2.7.6 Air

Area 1

- Analysis of air samples collected over a 2-day period from six locations around Site G and CS-B revealed organic contaminants in six samples from the first day of sampling, and in four samples from the second day. Contaminants in samples collected on the first day of sampling at Site G/CS-B included phenanthrene, fluoranthene, naphthalene, nitroaniline, pyrene, and

PCBs. Phenanthrene was detected in all samples, including the background sample. The remaining compounds were detected only in downwind samples. PCBs were the only contaminant detected on the second day of air sampling, and were detected only in downwind samples. PCB congeners (Aroclors 1248, 1254, and 1260) were detected in samples on both days at the same location near the northwest corner of Site G. These samples contained total PCB concentrations of 0.50 ug/m^3 the first day and 0.47 ug/m^3 the second day. All of the contaminants detected in downwind air samples at Site G/CS-B were also frequently detected in surface soil samples from Site G.

Area 2

- Analysis of air samples collected over a 2-day period from six locations around Sites Q and R revealed the presence of organic contaminants in four samples from each day of sampling. The background (upwind) samples for each day showed no organics. PCBs were detected in two samples (DC-19 and DC-20) from the first day of sampling, and in one sample (DC-26) from the second day of sampling. Samples DC-19 and DC-20 contained 0.07 ug/m^3 and 0.06 ug/m^3 of Aroclor 1260, respectively. Sample DC-26 contained a total PCB concentration of 0.41 ug/m^3 , including 0.19 ug/m^3 of Aroclor 1248, 0.13 ug/m^3 of Aroclor 1254, and 0.09 ug/m^3 of Aroclor 1260. Phenol was detected in downwind sample DC-20 at 0.04 ug/m^3 . This was the only semivolatile compound detected in air samples from Sites Q and R. Volatile organic contaminants were detected in two samples from the first day of sampling, and in three samples from the second day of sampling. The contaminant 1,1,1-trichloroethane was detected in all five of these samples, with a high concentration of 216 ug/m^3 . Two additional volatiles, toluene, and xylene, were detected in only one sample.
- With the exception of 1,1,1-trichloroethane, each of the contaminants detected in the air samples from Sites Q and R were also detected at high concentrations in subsurface soils at Site

Q. Two additional potential sources of volatile contamination are located to the east of the northern portion of Site Q. These include Trade Waste Incineration Services and Clayton Chemical Company. Neither of these facilities, however, handles PCB wastes.

7.2.8 Groundwater Transport Modeling

- Based on computer modeling of groundwater transport in the DCP area, contaminant loading to the Mississippi River was estimated using chemical data from the DCP and from Geraghty & Miller (1986). The estimated annual average loading of organics from all Area 1 and Area 2 sites is 47.93 lb/day. The estimated maximum loading from these sites is 89.3 lb/day. These figures represent loading from the shallow and intermediate zones of the unconsolidated aquifer only. Average and maximum contaminant loading from the deep zone (320 feet MSL to bedrock) were estimated to be 22 lb/day and 130 lb/day, respectively.
- Based on estimates of residence time for contaminants originating from each site, contaminants originating from Area 1 sites reach the Mississippi River in approximately 20 years, while contaminants originating from Area 2 sites reach the river in approximately 8 years.

7.2.9 Contamination Migration and Fate

- For contamination to cause an adverse effect on human health or the environment, each of the following is required: a source of contamination, release of the contaminant to a transport media, transport of the contaminant to a potential receptor location, exposure of the receptor to the contaminant, and exposure at a dose sufficient to produce an adverse effect. Investigations have detected contaminants in each medium: soils, groundwater, surface water and sediments, and air. Contaminated soil from waste disposal is the primary contaminant source.

- Contaminants detected in substantial quantities and concentrations at the DCP sites include volatile organics, semivolatile organics, PCBs, polycyclic aromatic hydrocarbons, and metals. Detected contaminants have mobility, persistence, and toxicity characteristics which could impact human health and the environment. Examination of contaminant sources, releases, pathways, and receptors indicates that numerous complete pathways for human exposure to DCP area contamination exist. In addition, based upon geologic, hydrologic, and contaminant characteristic information, numerous pathways for human exposure to DCP contamination were identified and classified as probably complete because investigations to date have not included sampling which would verify the completeness of the pathway. Finally, numerous other pathways for human exposure to DCP area contamination were identified and classified as potential pathways based upon limited field data and investigations to verify the completeness of the pathway.
- Environmental standards and criteria were examined relative to detected contaminant concentrations. Groundwater contamination concentrations detected at the DCP sites approach or exceed many MCL, MCLG, and HA drinking water standards or criteria. Several of the contaminants present in groundwater and the other media are carcinogens. The other contaminants are acutely or chronically toxic.

7.3 CONCLUSIONS

The following conclusions are based on the physical data collected during this investigation and the analytical results from sampling of the various media. Due to the complex nature of the project area, file information, various reports and publications, and historical aerial photographs have been used to supplement the physical and chemical data in developing these conclusions.

Area 1

- The analytical data from sediment sampling, the physical evidence of stained soils, discolored and oily water, and the presence of effluent pipe outlets in CS-A indicate that the contamination found in CS-A resulted from several sources. Organic contaminants detected in sediment samples from CS-A included chlorobenzene, pentachlorophenol, dichlorobenzenes, PAHs, and PCBs. Each of these contaminants was detected consistently and in various media at many of the DCP Area 1 and Area 2 sites. Each of the contaminants was also listed on waste inventories for Site R, which were submitted by Monsanto to IEPA. Additionally, IEPA and Illinois Attorney General's Office file information contain several reports of past direct discharge of process water and wastes from the Monsanto Krummrich Plant to Dead Creek. Historical aerial photographs show staining in CS-A resulted, at least in part, from direct discharge of waste materials from Monsanto.
- Although rough drainage and surface runoff from the Cerro property are only known continuing discharges to CS-A, the extreme discoloration and oily consistency of the water in CS-A suggests the existence of an ongoing unidentified source. The elevated concentrations of heavy metals, including copper, lead, and chromium, detected in surface water samples from CS-A support the supposition that discharges from the Cerro property have contributed to the contamination in CS-A.
- Because the culvert at Queeney Avenue is blocked, CS-A is effectively a surface impoundment, separated into two sections by fill material for an access road. The restriction of flow from CS-A has led to siltation of the creek bed, infiltration of retained surface water into the ground, and groundwater mounding beneath the creek in this area.
- Organic contaminants detected in sediment samples from CS-B include the same compounds detected in CS-A, plus several ad-

ditional volatile compounds. The commonality of detected contaminants between CS-A and CS-B indicates that flow from CS-A caused the deposition of contaminants in CS-B prior to the blockage of the culvert at Queeny Avenue.

- The presence of an effluent pipe on the west bank and the presence of rubbery material across a large area of the creek bed in the northern portion of CS-B substantiate reports of direct discharge of wastes to CS-B from the Midwest Rubber Company. This discharge probably occurred over an extended period of time, and probably contributed to the contamination in CS-B.
- The presence of an effluent pipe on the east bank, staining in the area of the pipe, and the detection of volatile contaminants not found in CS-A substantiate reports of direct discharge of wastes to CS-B from the former Waggoner Trucking Company at the property now occupied by Metro Construction Company.
- Because of the extremely high concentrations of contaminants detected in surficial soils at Site G and the uncontrolled nature of the site, surface runoff from the site may contribute to the contamination in CS-B.
- Based on groundwater level measurements collected during this investigation and creek bed elevations measured by IEPA, groundwater does not discharge into CS-B. However, groundwater is in contact with contaminated creek bed sediments, which extend to a depth of approximately 7 feet below the surface.
- A culvert at the southern end of CS-B under Judith Lane is blocked, preventing flow from CS-B to the south. Organic contaminants were detected at relatively high concentrations in subsurface sediments at both CS-A and CS-B. Blockage of the culverts at the south ends of these creek sectors has caused siltation, thereby increasing the observed depth of contamination.

- Surficial soils at Site G are highly contaminated with a variety of organic compounds. The contaminants detected at Site G were also found in various media across several other Area 1 and Area 2 sites. Based upon the contaminants detected at Site R, where Monsanto is the acknowledged and only source, the contaminants found at Site G indicate direct disposal of chemical wastes on the surface, with the likely source being Monsanto.

- Based on the analytical results of surface soil sampling across 32 grid sections in the central portion of Site G where the majority of contamination is located, approximately 1,480 yd³ of waste and fill material, with an average total organic concentration of 5,096 mg/kg, is present on the surface at the site. The volume estimate is based on analysis of only the top 6 inches of soils at Site G.

- The physical evidence of waste material in soil borings at Site G show that chemical wastes were disposed of to a maximum depth of 36 feet at the site. The contamination found in samples collected below the waste material and the physical evidence of staining in these samples show that contaminants are migrating in a vertical direction into deeper portions of the aquifer.

- Based on the depths of waste material found in soil borings at Site G and the horizontal distances between boring locations (depicted in Figures 4-8 and 4-9), a total volume of approximately 60,000 yd³ of contaminated waste and fill material is present in the subsurface of the site. Based on the results of subsurface samples G5-37, G7-69, and G8-70, which were each collected from the waste zone, the average total organic contaminant concentration of this material is 4,406 mg/kg. These figures do not include the volume or the contaminant concentrations of stained sand below the waste materials. The figures represent only rough estimates of contaminated soil and waste volumes.

- Based on historical aerial photographs and physical results of subsurface investigations at the sites, the former excavations at Sites H and I should be considered a single site.
- The physical evidence of waste material in soil borings at the two excavations across Sites H and I show that chemical waste disposal occurred to a maximum depth of 26 feet in each pit. The contamination found in samples collected below the waste material and the physical evidence of staining in these samples show that contaminants are migrating in a vertical direction to deeper portions of the aquifer.
- Based on the depths and thicknesses of waste material found in soil borings across Sites H and I, and the horizontal distances between boring locations, a total volume of approximately 200,000 yd³ of contaminated waste and fill material is present in the south pit. Based on the analytical results of samples collected from the waste zone in the south pit, the average total organic contamination concentration of the material is 12,218 mg/kg. Using similar data for the north pit, the total waste volume is estimated to be 50,000 yd³. Based upon the analytical results of samples collected from the waste zone in the north pit, the average total organic contamination concentration of the material is 6,300 mg/kg. The volume figures presented above do not include the volumes or contaminant concentrations of stained sand below waste materials in the pits. The figures represent rough estimates of contaminated waste and fill volumes.
- Groundwater has become contaminated at Area 1 sites as a result of waste disposal activities at Sites G, H, I, and L. An observed release in the shallow zone has been determined for each individual site within the study area by comparing contaminant concentrations from hydraulically downgradient wells to concentrations found in wells positioned hydraulically upgradient of

each site. The upgradient wells for Sites G, H, I, and L are EE-G102, EE-04, EE-20, and EE-G108 respectively.

- Results of groundwater sample analyses indicates that contamination has migrated both horizontally and vertically away from the disposal pits at Sites G, H, and I, and in a similar fashion away from the impoundment at Site L.
- At Site G, the horizontal migration of contaminants is evidenced by concentrations found in wells located outside the boundaries of the disposal pit. Concentrations in EE-11 are higher than concentrations in EE-05 because of its location close to the disposal pit. Concentrations found in EE-G106 may be the result of waste disposal at Site G and/or Site H, which is upgradient of EE-G106.
- At Site H, horizontal contaminant migration is evidenced by concentrations detected in wells EE-02 and EE-03, both of which are located immediately downgradient of the disposal pit.
- Similarly at Site I, horizontal contaminant migration is evidenced by concentrations detected in well EE-15, which is located downgradient of the disposal pit north of the Cerro Copper access road (old Queeny Avenue). Contaminated surface water leakage from CS-A may also be contributing to the contaminant concentrations detected in well EE-15.
- Contamination in Well EE-G109, located immediately downgradient of the impoundment at Site L, indicates that contaminants are migrating horizontally with the predominating groundwater flow direction.
- The presence of contamination in wells screened below the waste disposal pits (i.e., EE-G107, EE-01, EE-12, EE-14, and EE-16) at Sites G, H, and I indicates that contaminants are migrating in a vertical direction into deeper portions of the aquifer. The

presence of visibly stained sands below the pits, the detection of contamination in samples taken of these sands, and the predominantly downward vertical flow gradient provides additional evidence of vertical migration.

- Historical groundwater pumpage in the area has also facilitated the vertical migration of contaminants from these pits and probably accounts for the present distribution of contaminants in wells at Sites G, H, and I. From the late 1940s until approximately 1980, large groundwater withdrawals at Monsanto and surrounding industrial properties caused a significant lowering of the water table and the diversion of groundwater flow to a northerly direction toward the pumping locations. During the period of heaviest pumpage (approximately 1950 to 1970), groundwater levels were lowered as much as 50 feet below present day levels at the pumping locations, and 20 to 30 feet at Area 1 sites. Concurrently during this period, the pits at Site G, H, and I were excavated and filled. As a result of the pumpage, the water table was lowered 5 to 15 feet below the bottom of the pits during this period. Disposed liquids and leachate from the pits then infiltrated the unsaturated zone created below the pits (evidenced by stained materials below the pits) until they reached the water table. Once in the saturated zone, contaminants would have been transported in the direction of groundwater flow toward the pumping locations. After 1970, water levels rose into the waste materials at each pit. Flow diversion continued in a northerly direction until approximately 1980, when pumpage ceased and pre-pumping flow patterns were re-established.
- The present distribution of contamination of Area 1 wells supports the distribution pattern expected as the result of historical pumpage. The highest concentrations of contamination were found in wells screened below the disposal pits (wells EE-G107, EE-01, EE-12, EE-16, and EE-14) while wells located around the periphery of the pits (EE-05, EE-G101, EEG-102,

EE-03, EE-G110, EE-15, and EE-G112) show significantly less contamination. Although the latter group of wells are presently located downgradient of one or more of the disposal pits, because of pumpage, contaminants have historically been drawn in directions other than the natural direction of flow, following flowpaths to deeper portions of the aquifer than would have occurred naturally. The fact that contamination has only been migrating toward these locations since approximately 1980, when westerly flow was re-established, accounts for the relatively lesser amount of contamination found in these wells. Given the slow flow velocities calculated for the shallow zone and the distances contaminants must travel before reaching these wells, it is not surprising that only low concentrations of the more mobile contaminants (e.g., benzene, vinyl chloride, chloroform, toluene, and chlorobenzene) have been detected in these wells.

- The effects of historical pumpage on contaminant distribution at Site L is thought to be minimal because the impoundment at this site was not used for waste disposal until the early to mid-1970s, when heavy groundwater withdrawals were being phased out.
- A downward hydraulic gradient predominated between the shallow and intermediate zones of the unconsolidated aquifer at Area 1 sites. The effect of this gradient would be to drive contaminants from the shallow zone into the intermediate zone. Once in the intermediate zone, contaminants would be transported at a faster rate (due to higher permeabilities in this zone) than if they had remained in the shallow zone toward a point of discharge in the Mississippi River.
- Based upon computer modeling exercises, contaminants originating from Area 1 sites will be preferentially transported in the intermediate zone, and will reach the Mississippi River in approximately 20 years. Considering the extent and levels of contamination found across Area 1, each site is expected to contribute to contaminant loading to the river.

- The analytical results of air sampling conducted around Site G/CS-B show a documentable release of several contaminants resulting from surficial contamination at the sites. Both volatilization and the migration of dust containing contaminants are thought to be likely transport pathways for airborne contaminants.

Area 2

- Analysis of subsurface soil samples from Site O revealed the presence of many of the same contaminants detected in samples from Area 1 sites. Xylene, toluene, chlorobenzenes, pentachlorophenol, PAHs, and PCBs were each frequently detected at both Site O and the Area 1 sites. This commonality of contaminants indicates a common generator for the wastes at the various disposal sites in the DCP area.
- The same contaminants were also detected frequently and at high concentrations in previous subsurface soil and groundwater sampling at Sites O and R. The majority of the contaminants detected at the Area 2 sites were listed (or are byproducts of those listed) on Monsanto's waste inventories for Site R. The geographical proximity of the Area 2 sites, the similarity of contaminants detected (and therefore the likelihood of a common generator), and the presence of common pathways and receptors supports aggregating Sites O, Q, and R for HRS scoring.
- Although limited visual evidence of sludge or other waste material was encountered in soil borings at Site O, significant subsurface contamination was evidenced by the analytical results of soil samples. These results indicate that a greater volume of waste was once present in the lagoons, and that material may have been removed or may have seeped below the lagoon bottoms. Visual evidence of stained sand below the lagoons supports this possibility. Contamination was detected to a maximum depth of 20 feet at Site O. The presence of contamination at this depth, which is below the lagoon bottoms, indicates that contaminants

are migrating in a vertical direction into deeper portions of the aquifer.

- Previous subsurface soil sampling at Site Q revealed the presence of organic contaminants to a maximum depth of approximately 30 feet. The detection of extremely high concentrations of contaminants in subsurface soils at Site Q indicates that chemical waste disposal occurred in the northern portion of the site.
- The two waste inventories for Site R submitted to IEPA by Monsanto listed 28,270 and 16,021 yd³ for 1968 and 1971, respectively. Disposal operations at Site R occurred between the years 1957 and 1977. Based on these figures and other file information, at least 300,000 yd³ of chemical waste materials were disposed of at Site R.
- The analytical results of groundwater sampling at the Area 2 sites showed a positive release to the shallow zone from each site (O, Q, R), based upon comparative results from hydraulically upgradient and downgradient wells. The upgradient well for Site O is EE-21, while the upgradient well for both Sites Q and R is EE-17. Due to the presence of waste material in the subsurface across the property line between Sites Q (northern portion) and R, these sites should be considered a single disposal area.
- Groundwater sampling results for Site O showed only one significantly contaminated well. This well, EE-22, is located approximately 150 feet southeast of the actively pumping well at Clayton Chemical. Similar contaminants were detected in samples from both wells, although the concentrations detected in the Clayton well were much lower than those detected in EE-22. This data indicates that the Clayton well produces a slight cone of influence, drawing contaminants from the shallow zone at Site O into deeper portions of the aquifer to the west of the site.

- Based on the analytical results and the physical characteristics of the samples, liquid wastes are present to a depth of at least 40 feet at the "border" between Sites Q and R. Samples from wells EE-18, EE-19, and B-25A all showed high concentrations of organics, and each sample was extremely discolored and oily in consistency.
- The detection of organics in samples from wells in the southern portion of Site Q indicate that chemical waste disposal probably occurred in this area also. However, only relatively low concentrations were detected, and migration of contaminants from other sources to the east may have influenced the results.
- Groundwater pumpage from Monsanto's Ranney well #3 has affected contaminant migration in Area 2 in a similar manner as that shown for Area 1 sites. This well was used from the mid-1960s until the early 1970s, during the same period of time that the sludge dewatering lagoons at Site O, and disposal activities at Sites Q and R were in operation. The lowering of the water table and subsequent diversion of flow toward the Ranney well has caused contaminants to migrate off-site and into deeper portions of the aquifer.
- Both upward and downward hydraulic gradients occur between the shallow and intermediate zones at Area 2 sites in response to fluctuations in the Mississippi River stage.
- Based on data collected during this investigation and the results of computer modeling, the prevailing groundwater flow direction in both the shallow and intermediate zones is west-northwest toward the Mississippi River at Area 1 and Area 2 sites. However, at Area 2 sites, flow reversals occur when the Mississippi River stage rises above prevailing groundwater elevations. The eastward extent of flow reversal is dependent on the stage at which the Mississippi River crests. Flow re-

versals may approach Area 1 sites only during extremely high flood stage conditions.

- Prior to approximately 1980, contaminants migrating from both Area 1 and Area 2 sites were captured in the cones of depression created by pumpage at the Monsanto plant site and at Monsanto's Ranney well #3 near the river and transported to deeper portions of the aquifer. The reduction in groundwater pumpage in the DCP area has eliminated this mechanism for contaminant transport.
- The analytical results of air sampling conducted around Sites Q and R show a documentable release of PCBs and phenol resulting from past waste disposal activities at the sites. These contaminants were detected frequently at extremely high concentrations in previous subsurface sampling at Site Q. The wind directions encountered during the air sampling limit the source identification to Site Q since actual downwind sampling at Site R was not possible.
- Based on computer modeling exercises, contaminants originating at Area 2 sites will be discharged to the river in approximately 8 years. Each of the Area 2 sites has contributed to contaminant loading to the river. Without remediation, this loading is expected to continue, particularly from Sites Q and R.

Peripheral Sites

- The analytical results of sediment sampling in CS-C and CS-D showed the presence of organic contaminants in sediments at the south end of CS-D. Both surficial and subsurface sediments in this area contained organics, showing that the deposition of contaminated sediments has probably occurred for a substantial period of time. These results also indicate that organic contaminants are probably present in sediments in CS-E and CS-F. Additional investigation and sampling is necessary to quantify the potential risks associated with the contamination found in these creek sectors.

- The contaminants detected in sediment samples from CS-C and CS-D were common to those found in samples from CS-A and CS-B, indicating that previous flow and deposition from the northern portion of Dead Creek is probably the primary source for contaminants in CS-C and CS-D.
- Analysis of surface water samples from CS-C and CS-D showed no detected organic contaminants. Although the creek bed is heavily silted and vegetated, the lack of contaminants seen in the surface water results indicates that flow of water is basically unimpeded in the southern portion of Dead Creek.
- Analysis of surface water and sediment samples from Site M detected the same contaminants found in samples from CS-A and CS-B. Contaminants were generally detected at much lower concentrations in samples from Site M than in samples from CS-A and CS-B. In addition, the highest concentrations of contaminants at Site M were found in samples collected near the cut-through to CS-B. These results indicate that the contamination found at Site M may be due to flow between CS-B and Site M, rather than from waste disposal activity at Site M.
- Analysis of subsurface soil samples from peripheral Sites J, K, N, and P showed limited organic contamination at each of the sites. In many cases, the contaminants were similar to those detected at Area 1 and Area 2 sites, suggesting similar waste generators or migration of contaminants from other source areas used by these generators. Of these peripheral sites, only Site K contained significant evidence of chemical waste disposal activities. The relatively low concentrations of contaminants detected, plus the lack of physical evidence (staining, odors) in soil borings, suggest that Sites J, N, and P were not used for the disposal of chemical wastes, or were used on a limited basis.

- The analytical results of subsurface soil samples from Site J showed significant contamination in only one of the three samples collected. Contaminants detected in this sample included numerous identified and unidentified petroleum hydrocarbon components. Considering the nature of the operation at Site J (steel foundry), the source of the above contaminants is probably leaks or spills from the tank farm located to the east of Site J. Some additional contaminants which are not petroleum derivatives were also detected at low concentrations in samples from Site J. The presence of these compounds may be due to transport of contaminants in groundwater from other source areas to the east or south. One possible source for this supposition is the Moss American site, which is located to the southeast of Site J.
- Analysis of subsurface soil samples from Site K detected significant organic contamination in all three samples collected. These results and the physical evidence of staining in the samples indicate that the former excavation at Site K was used for the disposal of liquid chemical wastes. Evidence in historical aerial photographs supports this contention.
- Analytical results of subsurface soil sampling at Site N showed only limited organic contamination. Because each sample was collected from below the water table, the contamination detected may be due to groundwater contamination from another source. The soil borings at Site N showed little evidence of chemical waste disposal, and disposal activities at the site were probably limited to demolition debris and other construction wastes.
- Subsurface soils at Site P also showed only limited contamination. File information contains several reports of disposal of chemical containers and small volumes of chemical wastes. The analytical results indicate that some limited disposal of chemical wastes probably occurred at Site P.

- These findings and conclusions presented are directed only toward those sites in the DCP. Additional potential (and in some cases, probable) sources of contamination exist in the immediate area of the DCP sites. These sites may be contributing to some extent to the contamination detected at several of the DCP sites. The extremely high concentrations of contaminants detected at the DCP Area 1 and Area 2 sites, however, are obviously the result of chemical waste disposal activities at the DCP sites. The mention of other potential source areas is intended simply to emphasize the diversity and extent of contamination resulting from waste disposal activities in the Sauget area.
- The uncontrolled condition of waste materials present at Area 1, Area 2, and peripheral sites of the DCP provides numerous opportunities for contaminants to be released. Possible pathways for human exposure to contaminants at DCP sites range from simple pathways such as direct dermal contact with wastes and contaminated soils present on the surface to such complex pathways such as release of contaminants from buried wastes to the groundwater, and subsequent transport to the Mississippi River, where aquatic life bioaccumulates contaminants which are subsequently ingested by humans.
- Due to the limited use of groundwater by the general public in the area and the relatively slow rate of groundwater movement, contaminated groundwater poses a limited threat or hazard to area residents. Similarly, access controls to exposed waste and leachate tend to minimize the acute threat of public exposure to these materials.
- Chronic exposures to the persistent, mobile, toxic, and carcinogenic contaminants, released by DCP sites in surface waters, groundwater, sediments, and the atmosphere, represent potential health hazards to the public in the area.

- The area and population exposed to these contaminants will continue to grow unless mitigation activities are undertaken to control or eliminate releases of the contaminants to the environment.

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